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UNITED STATES DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, Secretary
BUREAU OF MINES
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U.S. Bureau of Mines

EXPLANATION OF TENTATIVE INSPECTION STANDARDS FOR ANTHRACITE MINES

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EXPLANATION OF TENTATIVE INSPECTION STANDARDS FOR ANTHRACITE MINES[1]

INTRODUCTION

This circular was prepared primarily to assist the Federal coal-mine inspectors through explanation, justification, and interpretation of the numerous safety recommendations contained in the Tentative Inspection Standards for Anthracite Mines, revised March 1944 and published as Bureau of Mines Information Circular 7282. It should also interest other persons who are concerned with coal-mine safety.

Numerous excerpts from Federal, State, and private publications have been inserted in the text; many of them are from the mining laws of several States. Other States have similar and equally meritorious mining laws dealing with various subjects discussed, but it is not practicable to quote all of these. Similarly, many of the excerpts are from Bureau of Mines publications, portions of which are based on the experience and writings of other agencies or individuals.

An extensive bibliography is appended to this paper, which will enable Federal inspectors and other readers to find more detailed information on a particular subject than is contained in the text; however, a complete bibliography of the various writings on mine-safety subjects referred to in the text would require listing several hundred references. Italicized figures in parentheses refer to items in the bibliography. Page and other citations following item numbers refer to the work cited and not to pages in this report. Standards starred (*) are of especial importance.

SURFACE CONDITIONS

SECTION 01. BREAKER AND CLEANING PLANT

Std. 01. To minimize fire, health, and accident hazards:

a. All switches and starting boxes should be enclosed.

b. Stoves or other heating devices should be properly and safely installed and of a type that will present the least possible fire hazard.

**c.* Thorough cleaning of coal dust and other refuse from the breaker should be done frequently and, if possible, daily.

**d.* Coal dust should be allayed with water or other wetting agent at points where large quantities of dust are released, or a dust-collecting system should be installed at such points.

**e.* Where coal is dumped at or near air intake openings, provision should be made to prevent the dust from entering the mine.

f. Coal dust should be kept from accumulating in or about any surface building as far as possible.

a. This is a fire-prevention precaution in compliance with regulations of the National Board of Fire Underwriters *(65)* and is discussed in Information Circular 6895 *(19):* "Switches shall not be placed in the immediate vicinity of easily ignitible material. When the conditions cannot be complied with, the

[1] Work on manuscript completed October 1944.

switches, unless of the oil-immersed type, shall be enclosed in metal boxes or cabinets and shall be of the externally operable type. * * * Starters shall have all live parts suitably enclosed" *(1, sec. 1108, p. 140; sec. 1312, p. 182).*

b. Preferably, all open-type heating devices and open stoves should be replaced by electrical "space heaters," or steam or hot-water pipes insulated from combustible material and properly installed to prevent contact and stumbling hazards.

If stoves are used, they should be located at a safe distance from all combustible material *(15, p. 66).* An air space of 4 inches should be provided between the ash box or bottom of the firing chamber and combustible floor. Such floors should be protected, beneath and surrounding the stoves, with sheet metal or asbestos covered with tile. Coal or wood stoves should be provided with stovepipe chimneys which should be kept in good repair, with tight joints, well-supported, regularly cleaned, and insulated from all combustible material *(15, pp. 73-74).*

c. This is to reduce the possible hazard of fires.

d. This is to remove or allay the dust particles that are often suspended at dumping points, conveyor transfer points, crushers or rolls, and car-loading places, and thereby reduce the dust hazard, increase visibility, and improve working conditions *(19, pp. 6-9).*

e. This is to prevent fine dust particles from contaminating the mine atmosphere.

f. This is to prevent unhealthful atmospheres in surface buildings and present favorable working environment.

Std. 02. Men working in or about breakers or cleaning plants should:
*a. Wear goggles if exposed to the hazard of flying particles.
*b. Wear suitable approved respirators when working in dusty atmospheres.

a. Goggles should be worn by any employee performing work in places where protection from dust and small flying particles is needed *(66, p. 2).*

b. "It is recommended that no worker be continuously subjected, without a protector, to an atmosphere containing any form of mineral dust in quantity exceeding 50 million particles per cubic foot" *(66, p. 1).*

Std. 03. Electric or acetylene welding or cutting in breaker or cleaning plants should be done preferably when the plant is idle; a fire extinguisher or container of clean, dry sand or rock dust should be readily available; and combustible surroundings should be wetted down before and after welding or cutting.

This recommendation is to prevent a possible ignition hazard of combustible material and can be considered an elementary fire-prevention measure. Cases are on record where disastrous fires have been started from this source. The requirement of a fire extinguisher is for the purpose of extinguishing any fire that may be started before it has had an opportunity to spread. The surface is wetted because the moisture would in most cases cool sparks and small pieces of metal below the ignition temperature of the combustible surface.

Std. 04. Where coal is treated with oil or other inflammable or harmful solutions, men exposed to the mist should wear suitable approved respirators *(81, pp. 12-13)*, and sources of ignition should be kept at safe distances from the spray.

"No worker shall be continuously subjected without a protector to an atmosphere proved to be hazardous to health" *(66, p. 1)*. Oil sprays are highly inflammable; consequently, ignition sources must be isolated to avoid possible fires or explosions.

SECTION 02. MINE-REFUSE DISPOSAL

Std. 01. Mine waste should be stored so as not to present fire, fume, or slide hazards as far as practicable.

The fire and fume hazards are caused by accidental or intentional firing of waste dumps. Burning waste dumps liberate poisonous and noxious gases, such as carbon monoxide, hydrogen sulfide, and sulfur dioxide. These gases are not only hazardous to persons on the surface where the dump is in the vicinity of inhabited buildings, but they may also be drawn into the mine where the dump is located near the mine intake-air openings.

If dumps are piled improperly, they may present hazards from slides to persons, animals, or buildings. Sparks from burning dumps, or brush fires started by them, might be carried to the mine openings or buildings and cause a fire. Locations of proposed waste dumps should be selected to preclude these hazards and so that the dump will not impound normal surface drainage and storm or seasonal flood drainage.

Std. 02. The waste dump should be fenced or protected by police or watchmen where there is possible hazard to persons, especially children, or to animals.

This recommendation is made to prevent accidents to persons and animals from gases, explosions (due to water encountering hot material), falls, and burns; incidentally, compliance with this recommendation will also prevent unauthorized coal picking, a practice from which many accidents originate.

Std. 03. Persons should not be permitted to live or work in buildings imminently endangered by fire, fume, or slide hazards from waste dumps.

This recommendation is self-explanatory. (See explanation 02-01.)

SECTION 03. HEAD FRAME

Std. 01. A railed platform should be provided at head sheaves.

"Every platform shall be provided with a *suitable* railing on all open sides 5 feet or more above the adjacent platform or ground level, except where there is a ramp, stairway, or fixed ladder" *(7, sec. 5, rule 51, p. 13)*.

Std. 02. The stairway leading to the sheave platform should be provided with handrails. Where ladders are used, they should be provided with substantial back guards.

"Every flight of stairs having four or more risers shall be equipped with standard stair railings or standard handrails" *(6)*. Back guards are a substitute for rest platforms, provide support in the event of rung failure or misstep where a person might be observing the surroundings rather than concentrating on the task of climbing the ladder.

SECTION 04. HOISTING

Std. 01. Machinery should be so placed that the noise from it will not prevent the hoisting engineer from hearing signals.

This recommendation should be carried out to avoid distraction to the engineer and confusion of signals and to provide a more suitable environment for the engineer. Concentration upon the task at hand is of paramount importance where men are hoisted or lowered, and noise is not conducive to clear thinking and prompt action should an emergency arise.

Std. 02. Hoisting engineers, whose duties in part are to hoist and lower men, should be physically fit and should undergo physical examinations at least annually to determine their continued fitness. A physician's report of such examination should be kept at the colliery.

Physical fitness is essential where a person is directly responsible for the lives of other persons. Several accidents and near accidents have occurred through sickness or collapse of hoisting engineers while on duty.

**Std. 03.* Unless the hoist is equipped with automatic overwind and overspeed and automatic stop controls that are tested daily, a second engineer should be in attendance while men are being hoisted or lowered.

This standard provides protection when men are being hoisted or lowered in case of sudden disablement or inattention of the hoist operator *(41, p. 15)*. The subject of automatic controls for hoists is covered in detail in a letter to district and subdistrict offices entitled "Hoist Protective Devices" *(17)*.

Std. 04. An empty cage or trip should be hoisted in any shaft or slope where the engine has been standing idle 1 hour or more before men are hoisted or lowered.

This standard is a reasonable test to avert mishap if some defect might have arisen during the idle period.

**Std. 05.* Hoist motors or engines should be of sufficient horsepower to hoist a fully loaded unbalanced cage or trip, and the hoists should be equipped with brakes capable of stopping and holding the fully loaded unbalanced cage or trip of cars at any point in the shaft or on the incline.

Obviously, motors or engines used to power shaft or slope hoists should be of sufficient horsepower to operate the cages or trips even under the most extreme conditions that may be encountered, because reserve power is always an asset as well as a safety factor.

"Shaft hoists shall have a brake that will keep the hoisting drum under the control of the operator. This brake shall be

provided with an automatic trip or release that will apply the brake in case the power supply fails, in case of overwinding or overspeeding, and this brake shall have sufficient capacity to hold the maximum unbalanced load" *(3, p. A–11)*. Similar safety requirements are found in Technical Paper 402 *(13)* and various State codes.

**Std. 06.* An accurate and reliable indicator of the cage or trip position should be so placed as to be in constant view of the engineer.

This precaution is required with respect to shaft or slope hoisting by many State mining laws; it is undoubtedly an excellent aid for the hoisting engineers and is a safety feature in that sudden stops are precluded when the engineer knows where the cage or trip is with respect to landings.

Std. 07. Drum guides or flanges should be high enough to prevent the rope from slipping off the drum.

These flanges may prevent the hoisting rope from slipping off the drum, falling, and winding around the drum axle. Cases are recorded where ropes slipped off drums and were severed or distorted causing, in some instances, run-away cars and in others disability of the hoisting equipment, which may be very inconvenient as well as expensive.

**Std. 08.* Hoisting equipment should be inspected daily and a record made of such inspection.

Where shaft or slope accidents have occurred because of failure of the hoisting equipment, they have been due almost always to lack of inspection and proper maintenance of the equipment rather than to inherent material weaknesses *(41, p. 15)*. Inspection is the first prerequisite for preventive maintenance, which obviously is the basic essential for the safe operation of machinery.

Std. 09. Sheaves should be inspected daily and kept properly lubricated, but these operations should not be done while the sheaves are in motion. The hoisting engineer should be advised by the inspector or oiler, in person, before and after the work is done. A record of the inspection should be kept.

See explanation for standard 08, this section. The stoppage of operation during the inspection is to safeguard the person making the inspection and to permit more thorough examination of the sheaves. The hoisting engineer is advised of the inspection to prevent movement while the examination is in progress, with possible injury to the person or persons making the examination.

Std. 10. A hoisting rope should be adequate in size to handle the load with proper factor of safety, as defined in wire-rope standards.

The rope should be of ample size to handle the maximum load to which it might be subjected without distortion. For sizes of rope for various loads, consult the various wire-rope standards. Some users of wire rope favor a safety factor of 10 *(51, p. 22)*.

Std. 11. The rope should make at least three full laps on the drum when extended to its maximum distance and should make at least one full lap on the drum shaft or around a spoke of the drum, and the end should be fastened securely by means of clamps.

This standard has been adopted as part of the safety rules of many companies *(51, p. 22)* and certainly is a necessary safety measure to prevent the rope from being disengaged from the drum.

Many hoisting engines powered by direct-current motors have a "free drum" to permit lowering the empty or loaded trains down an incline. In this arrangement, the drum is released from the drive shaft by manipulation of a friction clutch, and during the lowering operation the drum turns while the shaft remains idle. To have one full turn of the rope around the shaft causes wear of both the rope and shaft. To overcome this, the rope usually is fastened to one of the spokes of the drum with clamps. In such cases, the rope around a spoke of the drum with proper fastening by clamps is considered full compliance with that part of the standard recommending that the rope have one full lap on the drum shaft.

Std. 12. The rope should be fastened to its load by a socket filled with suitable metal, preferably zinc (spelter), or by a thimble and clamps or clips; the rope should be resocketed at least every 6 months. Where resocketing is done, not less than 4 feet should be cut off the end of rope, so that a new section of rope will be on the sheave when the cage is at the loading position.

This standard calls attention to good rope-fastening methods. Many individual companies recommend in their safety standards that cables be fastened to the load by spelter-filled (zinc-filled) sockets or by a thimble and clamps or clips. One company includes the following procedure to be used as a guide when resocketing ropes, "First, cut the cable end at right angles to its axis; then spread the wires and remove the length of hemp center equal to the depth of the rope socket or cone; then clean the wires thoroughly of all grease and oil; and then place the wires in the socket and fill the voids between the wires and the cone and the individual wires with molten zinc. For attaching the thimble and clamps, the rope is placed around the thimble and the first clamp or clip is placed 3 inches above the thimble. Each succeeding clamp or clip is placed six rope diameters apart, the last one being 4 inches from the end of the rope. The clips or clamps should not be staggered, and the saddles should bear against the live end of the rope with the U-bolts against the dead end" *(51, pp. 22-23)*.

Std. 13. Bridle chains that serve as a secondary safety connection between the rope and the cage should be provided.

Many mining companies as well as many State laws require the use of bridle chains. Bridle chains are safety devices, attached independent of the regular rope attachment, to hold the cage to the rope if a socket, hitching, or rope fails near the socket or cage *(51, p. 22)*.

Std. 14. A rope should not be used for hoisting men:

a. Which shows more than six broken wires in any single pitch length or lay of rope.

b. When the wires in the crown of the strand are worn to less than 65 percent of their original diameter.

c. When inspection indicates a dangerous amount of corrosion or distortion.

The standards *(a, b, c)* are excerpted from wire-rope specifications *(51, pp. 19-20)*, which of course were chosen as safe practices after exhaustive rope tests.

**Std. 15.* A record should be kept of the length of service of, or tonnage hoisted by, each hoisting rope, and the rope should be replaced as soon as there is evidence of undue weakness or other conditions which indicate that the rope may fail.

General records should be kept of the life of each rope, giving the name of the manufacturer, size, length, material, and type of construction of the rope; the date when it was put in service, number of trips made, or tons hoisted; the dates on which it was resocketed, lubricated, or cleaned; and the date it was removed from service. This information is valuable in determining about when renewal will be necessary. At the first sign of any dangerous condition the rope should, as the case may require, be resocketed or removed from service *(51, p. 19)*.

**Std. 16.* Ropes, links, chains, and rope sockets should be examined carefully by a competent person at least every day they are used, and records should be kept of such inspections.

Records eliminate the possibility of haphazard inspections since the inspector's signature appended to a report places a certain responsibility upon him. Such records also contain useful information for reference.

Std. 17. Rollers used on slopes or inclines should be of sufficient length, properly alined, and kept in good repair.

This precaution is necessary to maintain proper rope alinement, prevent excessive wear of the hoisting rope, and extend the life of the rollers.

Std. 18. At least two independent methods of signaling (one of which should be audible) should be provided on all landings in shafts or slopes.

Bell signals, telephones, pneumatic whistles, and speaking tubes are methods of signaling *(41, p. 17)*. A standby method or device is necessary because quite often one device may fail and such facilities are of prime importance in emergencies.

Std. 19. One of the signal devices at the surface and at each intermediate landing should be so located that it can be reached from the cage or car; or, at times other than when workmen are regularly hoisted or lowered with a topman and a footman on duty, a prearranged understanding should be had with the hoisting engineer before men are handled.

This is a safety precaution when a cager is not on duty to permit signaling from the cage or car after all persons are in the cage or car and ready to be transported. When signal

devices can be reached from the cage or car possible wrecks or mishaps may be averted and shaft or slope inspection is expedited.

Std. 20. The signal code in use at the mine should be posted prominently in the engine room in easy sight of the hoisting engineer and at all places where signals are given.

This is necessary to assist all persons giving or receiving signals and is required by the mining laws of many States. Places where signals are given should be construed to include engine rooms, surface landings, and each level or station.

SECTION 05. CAGES AND SHAFTS

**Std. 01.* Cages used for hoisting men should be of substantial construction, kept in good repair, and provided with:
- **a.* Adequate steel bonnets.
- **b.* Adequate side protection.
- **c.* Safety endgates.
- **d.* Handholds.

Every cage on which men are hoisted or lowered should be equipped with a suitable steel bonnet extending over the entire cage platform to protect the men from objects that might fall down the shaft.

Handholds provide support if the cage or car lurches suddenly because of possible sudden acceleration of the rope or a possible defective shaft guide. The sides of the cage should be enclosed and gates provided for the end enclosure to prevent persons from falling against shaft lining or timbering *(41, p. 16; 77 art. VIII, sec. 1, p. 57)*. Chains across the ends of the cage platform are not considered satisfactory substitutes for gates.

Std. 02. Cage safety catches that act quickly and effectively in an emergency should be provided, and they should be tested at least every 2 months and a written record kept of the test; where practicable, a drop test should be made. If it is not practicable to make a drop test of cages used for handling men, safety catches should be inspected daily.

Safety catches are devices for preventing a cage from descending a shaft in case of rope or hitching failure. When rope failure occurs, the safety catches grip the shaft guides and stop the cage. The catches are constructed and installed to function automatically if rope fails. The catches should be installed to permit free movement of the cage during ordinary operation, and they should be capable of stopping a fully loaded cage within a few feet when an emergency arises. Drop tests should be made to simulate actual conditions; otherwise, the complete operating mechanism is not tested. Good practice calls for frequent tests and accurate and complete records of the tests *(58)*.

Std. 03. Serious consideration should be given to equipping shaft-landing chairs at intermediate landings with automatic signals to indicate to the engineer the position of the landing chair, whether out in the shaft or back in the "clear." In addition, the levers that operate the landing chairs should be equipped with locking devices to secure them in the "clear" position when they are not in use.

Unless signals are installed, the engineer is never sure of the chair position and must assume an unnecessary responsibility for possible accidents over which he has no control.

Locking devices prevent accidental movement of the operating levers.

Std. 04. Cages, guides, and shafts should be inspected daily and maintained in good condition. Records of such inspections should be kept.

Daily inspections often disclose defects and thus avert mishaps. Frequent, thorough inspection is a worthwhile form of insurance. Many State mining laws require these examinations.

Std. 05. Any opening in the cage floor should be covered when men are handled.

Any opening is a possible falling hazard and a secure cover eliminates the hazard.

**Std. 06.* Wood-lined shafts should be fireproofed; if it is not practicable to fireproof them, adequate protection should be permitted against fire.

Wood lining may be fireproofed by the application of gunite to shaft timbers *(30, p. 6; 63, p. 37)*.

Mining companies have found that guniting is most successful when applied over wire-mesh cloth such as chicken wire or metal lathing. Moreover, actual tests have shown that timber would not burn when gunited in this manner *(71)*. Timbered shafts may be protected by applications of fire-retarding chemicals, such as diammonium phosphate, monammonium phosphate, monomagnesium phosphate, phosphoric acid, and zinc chloride (used alone or as chromated zinc chloride in combination with ammonium salts), or by application of fire-retardant coatings of cold-water paints, including whitewash, and special oil paints. However, the fire-retardant effect of all chemicals and paints is closely related to the quantity injected into the wood. Partial impregnation gives only a surface zone of protection *(15, p. 476)*. Therefore, this method of fire protection is not to be recommended because only a retarding effect can be obtained, and it is possible for shaft timbers so treated to burn readily.

Where it is not practicable to make shafts fireproof, they should be provided with automatic sprinkling devices, special water lines, or fire hydrants and hose, and fire doors should be constructed at the top or bottom of the shaft *(30, p. 7)*. (Construction of fire doors—see standard 01, section 11.)

**Std. 07.* A cager should be in charge at the top and one at the bottom of the shaft during periods when men are regularly handled. A cager riding the cage and giving the signals meets this recommendation. At times other than when men are regularly handled, with a topman and a footman on duty, a prearranged understanding should be had with the engineer.

This precaution is necessary to prevent confusion, overloading of cages, and crowding; to maintain discipline; and to permit giving and receiving signals properly. If a cager rides with the cage, the requirements are fulfilled.

Std. 08. Provisions should be made to prevent crowding and pushing where men are handled at shafts, slopes, and man-trip loading stations.

Man-trip cage or car waiting stations should be provided at points where men may congregate while waiting for transportation to the surface. Some official or other designated person should supervise loading and permit only the number of men that can be transported to leave the waiting station. This safety measure prevents possible accidents caused by crowding to board cages, man cars, or man-trips.

**Std. 09.* Shafts should be equipped with safety gates at the top and at any intermediate landings. The gates should be so constructed that materials will not go through or under them and into the shafts. This does not mean that gates should be of solid construction, which might obstruct the ventilation at these places.

This recommendation prevents persons or animals from falling into a shaft; if properly built, the gates will prevent tools or materials from being accidentally pushed into the shaft.

Std. 10. Positive stopblocks or derails should be placed at shaft landings.

Stopblocks and derails are necessary to prevent rolling stock that may get out of control or cars or trains insecurely blocked from entering the shaft.

**Std. 11.* Tools or other material should not be carried *in* the cage with men; however, this should not apply to equipment and repair material requiring attendants.

The transportation of tools or other material in cages with men constitutes a dangerous practice and violates many mining codes. Tools may be accidentally shifted to a position where they touch shaft timbers or projections and become flying objects injuring the cage occupants. A case is on record where several men were killed when drill steel was transported on the cage with the men. Explosives or detonators should not be transported on a cage with men *(39, p. 15)*.

Std. 12. The speed of cage when hoisting or lowering men should not exceed *900* feet per minute.

Rapid hoisting is not only dangerous but causes extreme discomfort to persons; in some cases nervous shock results from speedy ascent or descent. Many State laws limit man hoisting speed to 600 to 900 feet a minute *(39, p. 13)*.

Std. 13. Run-arounds should be provided for travel at the foot of shafts and at all intermediate landings. The run-around should not be less than 5 feet high and 3 feet wide.

This recommendation was formulated to prevent the unsafe practice of employees passing through the cage or clinging to shaft timbers to cross from one side of the shaft to the other. A passageway less than 3 feet wide and 5 feet high is not a reasonably accessible passageway. Many mining laws include

this recommendation *(77, art. VI, sec. 3, pp. 46-47; 87, art. 2, sec. 12, p. 20).*

Std. 14. While engaged in repair work in or above shafts, all workmen should wear safety belts. When a platform is being used, a second or safety platform should be placed not more than 10 feet beneath the working platform.

Obviously, the need for safety belts when performing work in or above shafts is unquestionable. A second or safety platform is an additional precaution to prevent serious injuries where the risk involved is great. A cage is quite often used for the safety platform.

SECTION 06. STEAM AND COMPRESSOR PLANTS

Std. 01. All boilers should receive at least one internal inspection annually by an authorized inspector, and a written record of such inspection should be kept.

All boilers should be thoroughly inspected at least yearly as a precaution against failure of material. This inspection is required by virtually all State boiler codes and casualty insurance companies. An authorized inspector is usually a person certified by the State as capable to perform this work *(4, sec. VI, parts 1 and 2).*

Std. 02. A safety-valve escape should not discharge lower than 7 feet above the floor; preferably the discharge should be piped to the outside of the building.

This standard is designed to prevent persons from being scalded by live steam from a safety-valve discharge.

Std. 03. At least two safe means of exit from all parts of the boiler room should be available, and the doors should open outward or sidewise, preferably outward.

This is to provide quick means of exit in emergencies such as boiler or steam-line failure.

Std. 04. A stairway or fixed ladder should be provided to give easy access to the top of boilers or runways between boilers.

A safe travelway to expedite the inspection and maintenance of boilers.

Std. 05. A fusible plug that will open at a temperature 50° less than the flash point of the lubricating oil in use should be placed in the main discharge line of compressors and as near the compressor as possible; or an equivalent protective device, such as a thermostat, should be used.

To reduce the danger of excessive temperatures and possible liberation of carbon monoxide into air supply lines, fusible safety plugs may be inserted in the discharge line *(57, p. 1929).* The purpose of fusible plugs is, first, to prevent an explosion of an air compressor because of overheating and the attendant excess pressure created thereby, and, second, to give warning of such overheating and tend to prevent carbon monoxide in distilled vapor formed from burning oil from entering com-

pressed-air lines and reaching men. Conceivably, other devices would serve the same purpose. For example, a thermostat control might be installed to stop the compressor when excessive temperatures existed. Any type of safety device that will prevent these dangerous conditions should be considered as compliance with the standard.

Std. 06. Main compressed-air receivers should be equipped with safety or relief valves and drain valves.

Std. 07. Compressed-air receivers should be inspected at least annually by a competent person, and a written record of such inspection should be kept.

These standards were formulated to protect equipment and persons from the dangers created when equipment is subjected to temperatures and pressures exceeding those for which it was designed. Inspections are a form of insurance against improper maintenance and defects, and the records establish responsibility. Many State codes require these safety devices and services.

Std. 08. Suitable gages should be provided for boilers and compressors (steam pressure, air pressure, water, etc.).

Each steam boiler shall have:

a. At least one water glass, the lowest visible part of which should be not less than 2 inches above the lowest permissible water level.

b. Three or more gage cocks, located within the range of the visible length of the water glass, when the maximum allowable working pressure exceeds 15 pounds a square inch, except when such boiler has two water glasses with independent connections to the boiler located on the same horizontal line and not less than 2 feet apart.

c. A steam gage connected to the steam space or to the water column or to its steam connection.

d. Each steam outlet from a power boiler (except safety-valve connections) should be fitted with a stop valve located as close as practicable to the boiler.

e. A blow-off pipe fitted with valve or cock, in direct connection with the lowest water space practicable *(4, appendix, secs. A-50–A-56, parts 1 and 2).*

A diagram of typical compressor installation, given in the Mining Engineers Handbook *(75),* compiled by Peele shows a compressor unit with pressure gages and gage cocks, provided for the air receiver and intercooler chamber, and a blow-off pipe fitted with valve or cock, in direct connection with the lowest point of the air receiver.

SECTION 07. WASH HOUSES

Std. 01. Wash houses should be provided in accordance with the State law, and they should be:

a. Provided with showers and an adequate supply of hot and cold water.

b. Kept clean and sanitary.

c. Provided with at least two exits.
d. Well-illuminated.
e. Provided with clothes lockers or hangers.
f. Kept well-heated and, if necessary, heating equipment guarded against contact hazard.
g. Properly ventilated.
h. Provided with sanitary toilet facilities.

These recommendations are made to provide healthful, sanitary conditions and to protect workers against possible colds, or sickness. Comfort and convenience are also provided *(55)*.

Where it is not feasible to provide a wash house, the condition should be clearly stated, so that a recommendation is obviated. An example might be a mine in a community where water is not available and the size of the facility would in no way warrant the expenditure.

SECTION 08. SUPPLY HOUSES

Std. 01. If oil or grease is stored in a building, the building should be of fire-resistant material and provided with a ventilator extending to near the floor level.

This is a fire-prevention measure, and ventilation is required to dissipate explosive or highly inflammable fumes. If screened openings in the wall are used in lieu of a pipe ventilator, the openings should be near the roof and near the floor.

Std. 02. Material should be stored so that it will not fall or cause a stumbling hazard.

Hazardous arrangement or piling of materials causes numerous accidents *(70)*. Obstructed walkways frequently are a source of serious injuries resulting from falls. Congested working areas decrease efficiency and tend to induce slovenliness and unsafe work habits.

Std. 03. Oil and grease should be stored in closed containers separate from other materials and in such manner as not to create a fire hazard.

The intent of this recommendation is to segregate a possible fire hazard; to avoid contamination of other materials, tools, and equipment; to provide better housekeeping; and to reduce slipping and falling hazards.

SECTION 09. LAMP HOUSE

Std. 01. Charging equipment should be guarded and protected against shock and fire hazards.

Insulating platforms or rubber mats, adequate working space, and enough illumination should be provided to reduce shock hazards. Moreover, charging equipment should be in a separate building or in a separate section of a building or room guarded in such manner as to prevent unauthorized entrance. The building or room containing the charging equipment should be well-ventilated to minimize any possibility of an explosion or fire caused by the ignition of hydrogen given off during the

charging of batteries. An adequate number of suitable fire extinguishers should be available in the lamp house.

Std. 02. Naphtha used for flame safety lamps should be stored in suitable containers, preferably at safe locations outside the lamp house, with an automatic filler spigot suitably placed within the lamp house.

Naphtha is highly volatile and inflammable and constitutes a a serious fire hazard if stored in open containers or in more than small quantities. Special safety-type dispensers and containers are available. Safety containers are equipped with special covers and faucets to prevent spillage and leakage *(15, p. 110)* if the containers are overturned, and the covers are usually attached so that misplacement is precluded and the cover is in place except during manipulation.

**Std. 03.* Flame safety lamps should be of the permissible type.

"Unapproved flame safety lamps may cause fires or ignite methane, and these should not be used" *(62)*. Lamps are approved by the Bureau only after exhaustive tests have been made and as many of the sources of ignition eliminated as possible; therefore, a permissible flame safety lamp properly assembled *assures the user* of an instrument with no defects. Approvals have been issued to the Koehler Manufacturing Co. and the Wolf Safety Lamp Co. *(46, p. 29)*.

**Std. 04.* Flame safety lamps should be properly cleaned, examined, and assembled by a lamp attendant after each period of use. Lamp assembly should again be checked by the person using it immediately before he enters the mine.

Gas ignitions and disastrous mine explosions have been caused by opening key-locked lamps within a mine and by the use of improperly assembled or defective lamps.

Lamp-testing boxes are available for testing flame safety lamps in explosive gas before use in a mine. These boxes are valuable for checking the assembly of a lamp, but the test of a lamp in such box is not a complete safeguard against improper lamp assembly or condition. The lamp-testing box is costly, and the time required to test a large number of lamps in a single or even multiple lamp-testing box might prove prohibitive. For these reasons, no recommendation of testing is made in this standard, even though in many instances the use of one would provide an additional safeguard. A lamp-testing box is described in Information Circular 7037 *(33, pp. 8-9)*.

Std. 05. When not in service, all methane indicators or detectors and flame safety lamps should be in the custody of a competent person responsible for their maintenance and testing.

This recommendation is to delegate the responsibility for safeguarding and maintaining valuable equipment to a competent, reliable person.

SECTION 10. YARDS AND MATERIAL STORAGE

Std. 01. Timbers, ties, and other mine lumber, other than 1 day's supply, should not be kept within 100 feet of any mine opening or mine fan if space is available. If space is not available, adequate fire protection should be readily accessible; and all materials, including rails, scrap iron, and other scrap, should be properly stored and piled so that they will not obstruct roadways, will not present stumbling hazards, and will not roll or fall.

The first part of this recommendation was formulated to eliminate a fire and fume hazard, since surface fires may be propagated to mine portals and fumes and smoke may be drawn into the mine with the intake-air current and jeopardize the lives of underground workers.

The second part of the recommendation is designed to prevent injuries caused by the rolling or falling of haphazardly piled material. Stumbling hazards contribute to injuries.

Std. 02. Roads, paths, and walks should be kept free from obstructions and should be well-illuminated if used by night shifts.

Insufficient and improperly applied illumination is a prolific cause of industrial accidents. Improper lighting has been found by investigation to be the greatest contributing factor to accidents in improperly lighted plants *(9, pp. 16-17)*. Similar plants with effective illumination have virtually eliminated accidents.

SECTION 11. SURFACE FIRE PROTECTION

**Std. 01.* All buildings within a radius of 100 feet of mine openings should be of fireproof or fire-resistant construction. If existing buildings within 100 feet of openings are not of fireproof or fire-resistant construction, fire doors should be erected at effective points (in shafts, drifts, or slopes) where smoke or fire from outside sources may endanger men working underground. These doors should be tested at least every 3 months to assure effective operation.

In several instances where inflammable structures were erected less than 100 feet from mine openings, surface fires have been communicated to underground workings, or the products of combustion from such fires have been drawn into the mine with resulting loss of life and damage to property. Records show that such fires have been responsible several times for causing the death of three or more men *(38)*.

Fire doors and their frames should be substantially constructed, should be covered with roofing iron or be otherwise fireproofed, should be tight, and should always be kept in repair *(35)*.

**Std. 02.* Adequate fire protection should be provided. Fire-fighting equipment should be readily accessible and the location of such equipment plainly marked.

Fire-fighting equipment should be available at every mine to protect against the spread of fires. The size of the mine, the water supply available, and the construction and location of surface buildings with respect to each other and the mine openings should be governing factors in determining the ade-

quacy of the fire protection afforded. Fire-fighting equipment may be classed as follows:

1. Stationary equipment, reservoirs or tanks, water lines, and hydrants on the surface, with necessary hose and nozzles.
2. Suitable portable or semiportable self-contained fire extinguishers for fighting fires of various origins.
3. Sand or rock dust.
4. Telephone and alarm apparatus.
5. Emergency fire doors (for mine shaft, drift, or slope openings).
6. Fire-fighting organization.

Electrical fires may be combated most effectively by the use of the following extinguishing agents: Carbon tetrachloride, liquid carbon dioxide, sand, and rock dust. Care must be exercised when using carbon tetrachloride or liquid carbon dioxide to ascertain that adequate ventilation or respiratory protection is used *(80, pp. 108-112)*. The equipment should be readily accessible to prevent delay in placing the apparatus in operation. Incipient fires are usually controlled readily, but each minute lost permits the flame to spread and increases the danger of combating the fire and the time required for control.

Std. 03. If municipal fire-department facilities are available, fire-hydrant couplings should be standard and interchangeable with those of municipal fire departments, or suitable adapters should be provided.

Adapters and connections are necessary to avoid delay if the plant equipment is not standard or the same size as that of the municipal fire department. Dimensions of standard fire-hose couplings are *(69)*:

Inside diameter, in.	*No. threads per inch*	*Length of thread, in.*
2½	7½	1
3	6	1⅛
3½	6	1⅛
4½	4	1¼

Standard pipe 3½ inches or more in diameter has eight threads to the inch and is not suitable.

**Std. 04.* Fire-fighting equipment should be inspected and tested at least every 6 months and records made of such inspections.

To be of any value, protective and emergency equipment must be maintained ready for immediate use, and the frequency of inspections recommended resulted from or is based upon years of experience by mining companies and industrial organizations.

Std. 05. A fire-fighting organization should be maintained and, if feasible, fire drills held at least twice a year.

An established, active, and well-trained fire-fighting organization is necessary to insure that capable men will be available and that any emergency will be handled by efficient working crews *(80, p. 114)*. The type and size of a fire-fighting organ-

ization will vary with the size of mine, the fire hazards present, and the availability of municipal fire departments to fight surface fires. At small mines employees should be trained in fighting fires and in the use of fire-fighting equipment.

Std. 06. Tight metal receptacles should be provided for oily waste.

Tight metal receptacles should be provided to reduce the hazard of fires started by the spontaneous ignition of oily waste, oily clothing, or wiping rags. These have caused disastrous fires. Containers should be covered tightly and should also be constructed substantially of metal or a suitable incombustible equivalent *(15, pp. 46-47)*.

**Std. 07.* Smoking in or about surface structures should be restricted to places where it will not create a fire or explosion hazard.

"Careless smokers and the careless use of matches by smokers are grouped together as one cause of fires because of the difficulty of always determining whether it is the cigarette, pipe, cigar, or the match used that is responsible for the loss." "Matches—Smoking" is the largest single fire cause, and the universality of smoking presents a difficult problem. Attempts to eliminate the hazard by prohibiting smoking are seldom successful except where rigid supervision can be maintained" *(15, p. 37)*.

SECTION 12. MISCELLANEOUS SURFACE CONDITIONS

Std. 01. Good housekeeping should be practiced in all buildings and structures and about the colliery yards.

Good housekeeping aids materially in preventing fire and stumbling hazards. Precariously piled materials are a hazard needlessly tolerated.

Std. 02. Passageways and places where men work should be well-illuminated.

Adequate lighting is necessary to avoid eye strain and numerous accidents which are attributed to inadequate illumination *(9, pp. 13-14)*. Effective lighting increases efficiency largely because groping and anxiety are eliminated.

Std. 03. Surface buildings should be well lighted and heated, if necessary.

The explanation of 12–02 is applicable to the first part of this standard. Heating is required for comfort, which in turn increases efficiency.

Std. 04. Surface stairways should not be set on angles of more than 45° with the horizontal if space is available. If the stairways are set on angles of more than 45°, they should be provided with proper guards.

This standard gives the maximum angle that is recommended in the American Safety Standards Code for Stairways and Ladders. Steeper angles increase both the stumbling and falling

hazards, and additional handholds may be necessary depending upon the location and frequency of use of the stairway.

Std. 05. Stairways should be provided with safe handrails and kept in good repair.

"Every flight of stairs having four or more risers shall be equipped with standard stair railings or standard handrails" *(6)*.

"Handrails for stairs:

"*(a)* Handrails of 36 inches (measured vertically) above the center of the tread, with an intermediate rail between the top rail and treads, shall be provided on each flight of stairs as follows:

"On all open sides.

"On one side of enclosed stairways 4 feet or less in width; preferably on both sides.

"On both sides of enclosed stairways 4 feet or more in width between rails.

"*(b)* All landings shall be provided with a 6-inch toeboard, or other enclosure in addition to rail" *(5)*.

(Also see explanation for standards 08 and 09 this section.)

Std. 06. The treads of stairways should present minimum slipping hazard and be of uniform construction and spacing.

Nonslipping construction requires that the treads be level, of adequate width, and surfaced in a manner to prevent slipping *(6)*. An abrasive material is frequently placed in recesses in the treads of smooth material.

Std. 07. Clearance over stairways should be at least 6½ feet. If adequate clearance cannot be obtained, illumination, or warning signs or devices should be provided.

This standard is designed to prevent head injuries primarily, although low ceilings or obstructions over stairways may result in other injuries to persons because of the discomfort and unnecessary body maneuvers made necessary to utilize the stairway. This recommendation is excerpted from the National Bureau of Standards recommendations for floors, openings, stairs, etc.

Std. 08. Permanent ladders should be provided with guards if necessary.

Std. 09. Openings in floors should be provided with toeboards and railings.

"Every floor opening shall be guarded by a railing of standard strength,* and standard anchorage. ***The railing shall be provided on all exposed sides (except at entrance to stairway). ***Standard toeboards shall be provided" *(7, sec. 3, rule 30)*.

*Wooden rails—posts to be 2 by 4 inches, spaced not to exceed 8 feet. Top rails to be at least 2 by 4-inch stock substantially constructed. Pipe railings—pipe must be at least 1¼ inches inside diameter for posts and top rails and at least 1-inch diameter for intermediate rails *(7, sec. 7, rule 72(a))*.

***The anchoring of posts and framing of members for railings of all types shall be of such construction that the completed structure shall be capable of withstanding a load of at least 200 pounds applied in any direction at any point of the top rail *(7, sec. 7, rule 72(d))*.

A suitable guard for a ladder is a semicircular one which, when attached to the ladder, forms an enclosed cylinder through which a man may climb, resting his back on the guard if desired. The guard should be attached securely to the ladder and capable of holding a man's weight. The guard should be so constructed that the only direction a person climbing the ladder could fall would be directly down the center of the cylinder. Such an arrangement *undoubtedly* would cause a man to become entangled with the ladder rungs or permit him to gain a hold thereon before he had fallen any appreciable distance.

MINING METHODS, CONDITIONS, AND EQUIPMENT

SECTION 13. TIMBERING

Std. 01. The timbering rules and safe timbering practices should be strictly enforced.

Accidents from falls of roof or coal usually are caused by lack of proper roof or face support.

With few exceptions, this can be blamed on the failure of the individual workman to remove loose material or to set timber, whether through carelessness or ignorance, although in a few instances lack of timber has been the contributing cause.

Experience has proved that under the same working conditions fewer accidents occur from falls at mines where timbering rules have been formulated and actually enforced.

Usually general timbering rules are adaptable with specific instruction and rules for special timbering and diagrams where possible will tend to induce good and consistent timbering practices.

No rule that has been studied, found applicable, and adopted is of value unless enforced.

**Std. 02.* An adequate supply of props, timbers, prepared cap pieces, and wedges, or material necessary for the same, should be provided convenient to the faces and other places of use.

Most State laws require the operator to furnish the props, cap pieces, and other timber necessary at a place convenient for the miners' use: in general, these timbers should be of approximately proper lengths and cut square at one or both ends *(26, p. 8)*.

Foremen, assistant foremen, or face bosses should by daily inspection and inquiry make sure that every employee who must timber be supplied with timber at a convenient point *(80, p. 93)*.

The lack of essential material tends to breed carelessness.

**Std. 03.* Miners should examine their working places thoroughly and make them safe before beginning work.

Each miner on entering his working place should "sound" the roof and feel with the fingers of one hand, or with another bar if the roof is high, to ascertain whether vibrations are discernible in the roof upon impact of a suitable tool. He should set props or timbers in places where loose material cannot be taken down *(80, p. 95)*.

When a miner enters his working place, the roof should be carefully observed with the light directed on it so that any crevices or movements may be detected. An official should remain until he has assured himself that his instructions to remove unsafe conditions have been carried out.

Std. 04. Every qualified miner should be instructed in the proper methods of testing roof, ribs, and face, including the vibration method.

Q. Is the sound test for roof reliable?

A. Sound tests are not always reliable because a dangerous piece of roof, especially if thick, often does not emit "drummy" or hollow sounds that can be detected by the ear.

A more reliable method, applicable to veins of coal less than 8 feet in thickness, is to place the finger tips of one hand lightly against the roof and with the other hand to strike the roof lightly with a testing bar. If the roof does not vibrate, a sharp, quick blow may produce the desired effect. A slow, heavy blow does not cause proper vibration. The degree of vibration as registered by the finger tips indicates the condition of the roof. In excavations more than 8 feet in height, the test should be made from a special scaffold or horse. *Do not stand under the piece of roof being tested.* Miners should test the roof frequently during the shift *(26, p. 7)*.

**Std. 05.* Exposed roof in every active working face should be tested at frequent intervals.

Some roof may sound solid when tested and fall soon afterward as a result of hidden slips or other unseen factors; therefore, to assure a greater degree of safety, tests should be made frequently and especially after the face or ribs have been disturbed.

Std. 06. Miners, mining-machine operators, and loading-machine operators should be provided with suitable roof-testing bars for testing the roof, face, and sides; any dangerous condition should be remedied immediately.

A testing bar particularly suitable for mine officials and machine operators can be made of a material that is a nonconductor of electricity, such as wood or fiber. It may have a metal cap or ferrule, as wood soon mushrooms and becomes less effective. The cap should be devoid of sharp edges. The bar should balance at a point about one-third the distance from the cap. The heavier the bar, within reasonable limits, the better it is for testing. The diameter should be 1 to 1½ inches and the length 3 to 5 feet or more to conform to the height of the coal bed *(26, p. 6)*. If such a rod is not available, proper tests can be made with a metal bar.

It is recommended that dangerous conditions should be remedied before machines are taken inby the last permanent timbers to prevent possible disturbance of the roof by movement of the machinery.

Machines should be stopped while the roof and sides are being tested to permit proper testing by eliminating false vibrations of roof or rib that may be caused by machinery in operation.

Std. 07. Officials should examine exposed roof, ribs, and face in working places visited and roof along haulageways and traveling ways; condition of timbering should also be observed.

Each supervising official should be required to carry a tool for testing the roof in each working place visited. He should also know definitely what to examine in each place, such as the roof, timbering, standing coal, manner of securing the car, and placement of shots.

The mine foreman or any supervisory assistant of the foreman is responsible for the safe condition of the roof in gangways and the roadway in chambers as well as the working face. * * * All parts of the mine traveled by men should have the roof tested daily, and in places where men are working the roof should be tested at least every 2 hours *(74)*.

Std. 08. Loose coal or rock in places where men are required to work or travel should be removed or supported securely.

This is necessary to prevent injury to men while in their working places or while traveling back and forth in haulageways or manways.

Std. 09. Before loose roof is taken down, the adjacent roof should be carefully examined and supported if necessary.

Careful testing of the roof, starting at a safe place, is the first essential; to insure safety of the workmen, safety props should be set as the work is advanced. Many mine accidents occur while men are digging hitches or doing other work preparatory to standing a prop, and a safety prop would protect the men while doing this. Workmen must be educated not to get under a loose piece of rock or roof containing cracks or crevices while testing, trimming, digging hitches, or doing any other work in connection with their tasks. The value of temporary protection cannot be overemphasized, since only limited information concerning the overlying strata is evident, and the unknown factors are difficult to handle.

Std. 10. If loose roof, ribs, or face material is being pried down, a bar of suitable length should be used instead of a pick.

A bar permits the person to work from a safe position while removing the rock or at least places the man in a less precarious position, whereas a pick necessitates working close to the rock or material being pried down *(39, p. 19; 80, p. 95; 82)*.

Std. 11. Timbers or props should be set as soon as room is available in working places. Forepoles should be used in working places where the nature of the roof and sides requires their use.

A degree of safety can only be assured when every known precaution is taken, and many accidents occur because the workman is slow in erecting timbers. A special effort should be made to stand props as soon as space can be cleared. Forepoles are really temporary protection and should be used where the roof is broken, if there is any doubt concerning the face inby the last timber or indication that ribs may slough off.

*Std. 12. Where conditions make it impossible to set permanent timber, props should be stood before loading is begun.

Where conditions or material prevents the erection of permanent timber, props should be set to prevent falls while preparations are being made to set permanent timbers. Temporary protection has undoubtedly lessened the number of roof-fall accidents *(26, p. 15)*.

Std. 13. Where there is danger of coal rolling upon a screen after undercutting, it should be spragged by placing blocks in the cut not more than 4 feet apart or by blocking with leaning props.

If the face is high—over 8 feet—and it seems at all liable to overturn or break, sprags or leaning props should be set against the face until all loose material is removed and sprags in the kerf prevent overturning of a block of coal left without support after undercutting *(80, p. 95)*.

Std. 14. In slopes or inclined shafts and in the main haulageways timber legs or props supporting the roof or sides should be hitched into the ribs or walls. If this is not practicable, substantial guard-rails should be placed along the sides or spacers (sprags) placed between the props or legs of timber sets.

In haulageways the legs of timber sets or props should be recessed into the ribs so that derailed equipment will not dislodge the props or timbers *(80, p. 94)*.

Q. What precautions are advisable to prevent props from being dislodged by derailed cars or other track-mounted equipment?

A. The safest plan is to place props or timber legs in a recess in the ribs. * * * Where props are placed in a line near the haulage track, planks attached to the props give much protection against dislodging timbers if cars are derailed. Clearance should be adequate between roadside props and mine cars. At least 18 inches between the props and track on the "tight" side of gangways and 3 feet between props and track on the clearance side of gangways should be maintained *(26, p. 27)*. Spacers or braces between props or timber legs afford considerable protection against dislodgment of timbers.

Std. 15. Props should be set with cap pieces where practicable; the foot of the prop should be *hitched into the bottom.*

A cap piece affords a cushion for the top of the prop and presents a greater bearing surface against the roof, especially where the roof material contains numerous cracks or disintegrates readily upon exposure to air and moisture *(26, p. 13)*. Hitching assists in preventing dislodgment by flying material, canting by roof movement, and possible movement by derailed equipment.

Std. 16. Cap pieces should be of adequate thickness and length and at least as wide as the top of the prop. Where it is necessary to use cap pieces, if practicable, they should be at least 18 inches in length and 3 inches or more in thickness.

Cap pieces should be of adequate size and thickness to be effective. The cap-piece material should be strong enough so that the load is spread through the cap *(80, p. 94)*. A cap piece can be too long and too thick for safety and efficiency *(26, p. 14)*.

**Std. 17.* Miners or other employees should not go under rock or other loose roof material, except to secure it.

This is a self-explanatory safety precaution to aid in the prevention of accidents from falls of roof or ribs. Chance-taking results in numerous accidents.

Std. 18. Broken and decayed timbers should be replaced as soon as possible.

This is self-explanatory. A defective support is an additional hazard.

**Std. 19.* Timbers or props knocked out by blasting or otherwise should be replaced as soon as possible.

The release of support permits additional subsidence and possible weakening or breaking of overlying or adjoining strata; thus, supports removed in any accidental manner should be replaced as soon as possible.

Std. 20. Where conditions permit in pillar work, break-line props or cribs should be maintained at the loose ends of pillars and stumps.

Support is particularly important adjacent to caved areas to prevent strains from being transmitted to the roof overlying pillars, with resultant unnecessary fracturing of the roof over the pillars *(80, p. 94)*.

SECTION 14. EXPLOSIVES AND BLASTING

Std. 01. Separate surface magazines should be provided for the storage of explosives and detonators.

The Regulations (March 1944) issued under the Federal Explosives Act *(12)* provide for appropriate storage facilities for all explosives and ingredients of explosives and give detailed magazine construction and location requirements. Note that suspension or modification of storage and handling requirements may be requested by a licensee, in writing, to the Explosives Control Division, Bureau of Mines, Washington, D. C.

Std. 02. Detonators should be stored in a separate magazine of incombustible material or the magazine covered with fire-resistant material and located not less than 100 feet unbarricaded, or 50 feet barricaded, from a magazine containing explosives.

Refer to standard 01 and standard 03*a*, this section. The location should comply with the American Table of Distances (1919 revision) *(8)*.

This precaution is a requirement in regulations for explosives manufacturers or users and is outlined in the Blasters' Handbook. Detonator-storage magazines need not be as large or elaborate as explosives-storage magazines; however, they must

be constructed of fire-resisting material and so removed as not to create a hazard.

Std. 03. Surface explosives-storage magazines should be:
- *a.* Constructed of incombustible material or covered with fire-resistant material and be reasonably bulletproof.
- *b.* Located in accordance with the American Table of Distances so far as feasible and be not less than 200 feet from any mine opening or vital structure.
- *c.* Located a safe distance from burning waste dumps.
- *d.* Provided with suitable danger signs properly placed near the magazines.
- *e.* Provided with proper ventilators effectively screened.
- *f.* Provided with proper doors.
- *g.* Kept locked securely at all times when not being used.
- *h.* On suitably drained locations.

a. In the Regulations issued under the Federal Explosives Act, requirement is made that "all high explosives in amounts exceeding 125 pounds shall be stored in permanent magazines which are theft-resistant, fire-resistant, and bullet-resistant."

High explosives in amounts of 125 pounds or less are to be stored in permanent magazines or "in box-type magazines which are theft-resistant." There are detailed provisions regarding the construction of these magazines.

Low explosives in amounts exceeding 125 pounds are to be stored in magazines of the same type as those used with high explosives except that the magazine need not be bullet-resistant. "Any metal magazines shall be lined with a nonsparking material."

Detonators are not to be stored "in any magazine containing high or low explosives or blasting-device heaters." Storage of detonators in numbers of 1,000,000 or more has the same magazine requirements as for high explosives in quantities exceeding 125 pounds. Storage in numbers of more than 5,000 and less than 1,000,000 has the same magazine requirements as those for low explosives in amounts exceeding 125 pounds. Detonators in numbers of 5,000 or less may be stored in box-type magazines.

b. See American Table of Distances, 1919 Revision, for the storing of explosives and detonators in various quantities with reference to other explosives, inhabited buildings, public railways, and public highways.

The provision "insofar as feasible" is inserted because situations arise where the topography or other *physical* condition may prevent the location of a magazine in conformity to the American Table of Distances; also, security considerations as to location as well as safety may enter the problem.

c. The distance should be such as to afford no hazard from a dump fire or slide that might affect the magazine.

d. The Regulations issued under the Federal Explosives Act provide that "the premises on which a permanent magazine is located shall be conspicuously marked by signs containing the words 'Explosives—Keep Off.' Such signs shall adequately warn any person approaching the magazine of the presence of explosives, but the signs shall not be so placed as to direct general

public attention to the location of the magazine. No signs shall be placed on surface magazines or barricades or be so located that a bullet passing directly through the face of a sign will strike the magazine."

e. The Federal Explosives Regulations provide that "Foundation vents shall be of an offset-type construction, and all vents shall be effectively protected with metal screening or otherwise constructed to prevent the entrance of persons, animals, sparks, or firebrands or the direct penetration of bullets that can detonate the explosives."

f. The Federal Explosives Regulations provide that: "Doors of magazines on or exposed to the surface of the ground shall be constructed of ⅜-inch steel plate lined with a 2-inch thickness of wood; or of a thinner steel plate lined with a greater thickness of wood, at the rate of 1 additional inch of wood for each ⅛-inch decrease in the thickness of the steel plate; or of wooden walls at least 4 inches apart and filled with screened sand or other effective bullet-resistant filler, the exterior being covered with sheet iron not lighter than No. 26 gage, or other fire-resistant material; or of wood not less than 6 inches in thickness; or of reinforced concrete not less than 4 inches in thickness. Doors of magazines located underground shall be substantially constructed of wood not less than 2 inches in thickness or of other material of equivalent or greater strength."

g. The Federal Explosives Regulations provide that: "Doors of all permanent magazines shall be equipped with two mortise locks; or with two padlocks fastened in separate hasps and staples; or with a combination of a mortise lock and a padlock; or with a mortise lock that requires two keys to open; or with a three-point lock. Padlocks and mortise locks shall be the equivalent of five-tumbler jarproof locks. Doors shall be provided with strong hinges, hasps, and staples attached by welds, rivets, or by bolts fitted with lockwashers and nuts on the inside of the magazine and installed in such a manner that the fastening cannot be removed when the magazine is locked."

h. This recommendation is to prevent deterioration of explosives from water or moisture which might get into the magazine.

Std. 04. The area surrounding the magazine for not less than 25 feet, preferably 50 feet, in all directions should be kept free of rubbish, dry grass, or other material of a combustible nature; preferably, this area should be covered with some material to prevent the growth of grass, brush, and weeds.

This recommendation *(83, p. 13)* constitutes a safety precaution to prevent the spread of possible brush fires to explosives magazines, and a similar requirement is contained in some State codes.

Std. 05. If the explosives magazine is illuminated electrically, the lamps should be of vaporproof type, the switch should be located outside the building, and the wiring should be in conduit.

This recommendation is almost identical to that of the National Fire Protection Association recommendation for build-

ings used for the storage of inflammable liquids *(68, sec. 40, item 44, p. 197)*. Fires in magazines would be extreme hazards, and unprotected light globes and haphazard wiring, as well as open switches, are possible sources of ignition.

Std. 06. Magazines for distributing explosives or detonators should be of the same type of construction as storage magazines and situated not less than 200 feet from any mine opening or vital structure.

This recommendation is made as a precautionary measure to protect vital structures such as a hoist house, dam, bridge, mine shaft, tunnel, or slope opening at the surface from damage if an explosion occurs in a distributing magazine. This standard and standard 14–03 should not be construed as barring box-type magazines.

Std. 07. Not more than 1 day's supply of explosives should be kept in a distributing magazine.

Distributing magazines are usually near operative or vital structures, and these magazines often are not as well-constructed as main storage magazines; therefore, the contents should be limited to 1 day's supply.

Std. 08. Detonators, tools, or materials other than explosives should not be stored in an explosives magazine; however, this does not prevent the storing of safety fuse or detonating fuse (used for outside blasting) or blasting supplies in any explosives or detonator magazine.

The recommendation that detonators should not be stored with explosives obviously is designed to prevent accidental ignition of detonators from detonating explosives. The Federal Explosives Regulations provide: "No detonator shall be stored in any magazine containing high or low explosives or blasting-device heaters." The recommendation that tools and materials other than explosives be kept out of explosives magazines is designed to minimize the need for access to explosives magazines by various persons as well as to permit proper explosives storage without the complications of handling tools within magazines.

Std. 09. Unauthorized persons should not be permitted in any magazine.

Access to explosives magazines is restricted by the Federal Explosives Act Regulations *(12, sec. 301.24e(2))* to persons individually licensed under the Act, to persons accompanied by licensed individuals, to designated officials of the Bureau of Mines, and to Federal, State, or local law-enforcement officers or investigators, who are authorized to inspect places where explosives or explosives ingredients are stored.

Std. 10. Only hardwood or nonsparking plastic tools should be used for opening containers of explosives and detonators.

This recommendation *(18, pp. 75-76)* is made to avoid ignitions from sparks made in opening containers with metal tools.

Std. 11. Waste paper and empty boxes should not be allowed to accumulate in explosives or detonator magazines.

Waste paper, empty boxes, and other trash constitute a fire hazard and consequently should not be allowed in or near explosives magazines of any type *(18, pp. 69-70)*.

Std. 12. Smoking, and carrying matches and smokers' articles, open lights, or open flame should not be allowed in or near any magazine, or while handling explosives or detonators.

This is a fire- and explosion-prevention measure.

Std. 13. Containers of explosives or detonators should always be lifted and set down carefully, never slid over one another or dropped from one level to another.

This precaution *(18, p. 63)* is necessary to avoid the possibility of frictional sparks, static charges, sparks, or impact, any of which under certain conditions could detonate the explosives being handled.

Std. 14. Deteriorated or damaged explosives or detonators should be destroyed. This operation should be done only by a person who is experienced in this work, preferably a technical representative of a manufacturer of explosives.

Deteriorated explosives and detonators often will fail to explode, causing misfires, or the explosives will burn, releasing poisonous fumes.

Explosives that show obvious signs of deterioration, such as hardness, discoloration, excessive softness, or leakage from the container or containing wrapper, should be destroyed. When in this condition, the explosives should be handled with extreme care because their sensitivity may be greatly increased.

Many accidents have been reported that had resulted from improper disposition of deteriorated explosives. Therefore, only a person experienced in this work, preferably a technical representative of a manufacturer of explosives, should attempt to destroy deteriorated explosives or detonators *(18, p. 73)*.

Std. 15. Vehicles used in surface transportation of explosives should be substantially constructed, have tight bodies with no internally exposed metal, and be kept in good working order. Open vehicles should be provided with tarpaulins. The ends and sides of the vehicles should be high enough to prevent containers from falling or rolling off.

This standard embodies a number of the recommendations made in the Blasters' Handbook on transportation of explosives. The Interstate Commerce Commission Regulations govern the transportation of explosives in interstate commerce.

Std. 16. State or other regulations as to marking vehicles transporting explosives should be complied with. If no laws or regulations are in effect, any such vehicle should be placarded on each side and rear with the word EXPLOSIVES in letters not less than 3 inches high or should display a red flag with the word DANGER in white letters not less than 6 inches high.

For interstate commerce the Regulations *(54, sec. 7.1052 and 7.1053)* referred to under standard 15 provide that whenever

any quantity whatever of any dangerous explosive is being transported on any motor vehicle, such vehicle shall be marked "EXPLOSIVES" by means of signs or lettering on each side and the rear of the motor vehicle, and the letters shall be at least 3 inches high on a background of sharply contrasting color.

Std. 17. Unauthorized persons should not be permitted to ride on vehicles transporting explosives, and the driver and helper should not smoke or carry matches or lighters.

Std. 18. A vehicle containing explosives should never be left standing or unloaded until the motor has first been stopped and the brakes set securely and should never be taken into a garage or repair shop. Explosives cases should never be left immediately back of the exhaust, as a spark may start a fire or cause an explosion.

These standards are formulated to minimize the hazards inherent in the transportation of explosives.

Std. 19. Explosives or detonators should never be left unattended until they are placed in a magazine and the magazine is locked or are delivered to someone authorized to receive them.

The Regulations issued under the Federal Explosives Act provide: "Whenever explosives or ingredients of explosives are in the process of manufacture, or whenever explosives or ingredients of explosives in use in the operations of a licensee, not in excess of a daily supply, are not stored in accordance with the requirements for storage in these Regulations, or whenever explosives or ingredients of explosives are being physically transferred from one person to another or are being otherwise physically handled on the operating premises of a licensee, they must be continuously and effectively guarded to protect them against theft. Any person guarding explosives or ingredients of explosives shall be a licensee or an employee of a licensee to whom the explosives or ingredients have been distributed by a licensed foreman."

Std. 20. Records should be kept of all explosives and detonators received, stored, and issued.

The Regulations issued under the Federal Explosives Act provide (section 14*d*, 3 and 4) that:

"(3) *Purchaser.* The record of a person having a purchaser's license must include the following information: The amounts and kinds acquired, the names and addresses of the persons from whom acquired, and the dates on which acquired; the amounts and kinds used, the purposes for which used, the places where used, and the dates on which used; and the amounts and kinds on hand at each location at the end of each day on which there are transactions or operations."

"(4) *Foreman.* The record of a person having a foreman's license must include the following information: The amounts and kinds acquired, the names and addresses of the persons from whom acquired, and the dates on which acquired; the names and addresses of the employees to whom sold or issued or from whom returned and the dates on which and the amounts in which sold, issued, or returned; the amounts and

kinds on hand at each location at the end of each day on which there are transactions or operations; and such other information as may be required by section 20*(d)*."

This requirement of records is to prevent theft and misuse of explosives.

**Std. 21.* Individual boxes (such as those of wood, plastic, or pressed fiber) or receptacles (such as rubberized or leather bags) used to carry explosives or detonators into mines should be closed and constructed substantially of nonconductive material and maintained in good condition.

The fundamental reasons for this standard and numerous others following regarding explosives are to avoid the possibility of ignition or premature detonation of explosives through electrical contact or impact in rough handling.

Std. 22. When explosives and detonators are transported underground by locomotive, rope, or belt:

**a.* They should be in specially designed cars or in specially designed containers:

(1) The bodies of such specially designed cars should be constructed substantially of nonconductive material and should be fully insulated. Insulated couplings should be used to complete full insulation if necessary. When cars contain explosives or detonators, they should be locked or attended at all times.

(2) Specially designed containers should be of wood approximately 2 inches in thickness; they should be fully insulated and locked securely when not attended.

**b.* If explosives and detonators are hauled in the same explosives car or in the same specially designed container, they should be separated by at least a 4-inch substantially fastened wooden partition or the equivalent.

An explosives car *(18, p. 72; 73)* should be rugged in construction, covered, and insulated adequately from electric current. The car may be of wood, lined with asbestos or rubber, or of metal, lined with wood, and all interior nails and screws countersunk and covered with an insulating compound so there is no metal exposure whatever; or the car may be of wood with similar interior modeling. Good construction embodies two boxes, the inner or explosives-storage box having no metal projecting on the inside and having compartments designed for the explosives boxes or receptacles to be placed therein. Where applicable, side doors for access to explosives should open only on the side of the gangway opposite the trolley wire.

If bonds are defective or if trolley locomotives are run onto a layer of sand on the rails, current may be shunted through the drawbars of the cars; and if the insulation in the explosives car is ineffective, the explosives may be detonated or ignited. Therefore, an insulated coupling on an explosives car is recommended, unless the car is constructed so as to be completely insulated.

In insulated couplings *(72)* the piece containing the hole for the coupling pin is made of steel, and the steel parts are separated by an insulating material such as fiber or wood. The

coupling is either rigid or semirigid to prevent the bumpers of the mine cars from coming in contact and to keep the cars insulated from one another at all times.

In one simple and easily constructed insulated coupling, a wood block 3 by 10 by 11¾ inches is used as insulation. Two pieces of strap iron ⅝ by 4 by 12 inches are spot-welded to two other pieces of strap iron ⅝ by 3 by 12 inches to form T-shaped pieces. The T-end of each piece is placed in a groove in each end of the wood block. Three ½- by 5-inch bolts fasten each strap iron to the wood block. The wood-block ends are rounded and faced with a ⅝-inch steel strap. Three inches from the end of each steel strap a hole is provided for coupling pins. The coupling-pin holes are 20 inches center to center, so car bumpers are not likely to touch each other. With this coupling approximately a 2-inch spark gap intervenes between the metal coupling straps, and about 6 inches of wood separates the bolts. (Refer to Bureau of Mines Report of Investigations 2868, April 1928.)

Std. 23. When feasible, the supply of explosives should be delivered on the off shift or between shifts.

**Std. 24.* Explosives or detonators should not be carried on the same trip with workmen or by the same person at the same time.

**Std. 25.* Trips carrying explosives should not be hauled into or out of a mine within 5 minutes preceding or following man-trips. When traveling with the air current, the explosives trip should precede; if against the air current, the man-trip should precede.

These recommendations (standards 23, 24, and 25) are to avoid the possibility of ignition or premature detonation of explosives in the vicinity of large groups of men. Selecting periods when there are few men in the mine and segregating the explosives from men are precautions to prevent exposing men to a possible premature explosion.

Std. 26. Explosives and detonators for use at the faces should be kept in separate boxes or in well-constructed, two-compartment boxes having well-fastened, adequate separating partitions of wood not less than 4 inches in thickness. These boxes should be kept at safe locations removed from the working faces, and tools or other materials should not be stored with explosives or detonators. The quantity of explosives kept in a miner's box should be limited to as nearly 24 hours' supply as possible. In pillar work the foreman should designate a safe place where explosives should be kept.

This paragraph applies to the safekeeping of explosives near the working faces for the use of miners or shot firers during each shift.

The provision of separate boxes or well-constructed two-compartment boxes is to prevent possible detonation when other objects are placed in or removed from a box. If accidental detonation should occur and the explosives and detonators are separated, the possibility of discharging the explosives is remote. "Safe locations" means isolated places out of the line of fire, free from roof hazards, where a fall of rock might discharge detonators or explosives, and away from ordinary travelways to mitigate the hazard to other persons who may have occasion

to work or travel in the vicinity and also to prevent some careless act of another person from accidentally causing a premature detonation or explosion.

Limiting the quantity in storage to 1 day's supply lessens the hazard present with large quantities, as well as the possibility of loss and deterioration *(18, p. 74)*.

Because of the almost continuous movement of the coal and strata in pillar sections, safe places should be designated by the foreman owing to his knowledge of the section and the necessary movement of persons and materials.

Std. 27. In underground operations, explosives and detonator boxes should be:

a. Placed in a crosscut (heading) or abandoned chamber or breast neck as far away from the roadway as to be safe; at least 25 feet from trolley or power wires; in a comparatively dry place; and at least 10 feet from the tracks where space is available.

b. Kept locked at all times, except when explosives supplies are being placed in them or removed.

c. Protected from falls of roof.

d. Constructed substantially and, if of metal, with electrically nonconducting lining.

Operation boxes or magazines are generally used, one in each section, from which the explosives and detonators are distributed to the miners or where they are used only by shot firers. In any case they usually contain enough explosives for a day's supply for a large number of working places.

a. This recommendation is made in an attempt to isolate and protect the explosives from possible ignition caused by haulage accidents, electric currents, and fires caused by the trolley or power wires.

b. This recommendation is designed to prevent theft of explosives for sabotage or other purposes.

c and *d.* These recommendations are to prevent damage to or detonation of explosives from falls of roof or from electrical contact. The roof should be well-supported by timbers and tested frequently.

The recommendation regarding power wires in *a* would prevent electric lighting other than portable lamps at or within 25 feet of underground operation boxes or magazines. However, if fixed lighting is desired nearer, it will be satisfactory to consider as compliance with this standard lamp or lamps of vaporproof type, installed near but not directly above the operation box, wiring to lamp in conduit, and switch several feet from the explosives-storage box.

Std. 28. Only permissible explosives should be used for blasting coal or rock. All shots in coal should be fired with permissible shot-firing units, if it is possible to procure them; whenever feasible, shots in rock should be fired with permissible shot-firing units. *In anthracite mines* permissible explosives are recommended, owing to their greater factor of safety as compared with other explosives used in blasting coal or rock.

Permissible explosives are recommended because if they are used in a permissible manner, they are much less likely to ignite explosive gas than nonpermissible explosives.

The permissibility of shot-firing units is determined by the safety and adequacy of performance. The permissibility tests *(48)* insure that the units shall not be capable of igniting methane and air mixtures; live terminals shall be protected to prevent accidental contact, and the battery (if of the storage type) shall not leak electrolyte under conditions of use. Each unit must have its rated firing capacity and be mechanically strong so as to have reasonably long life. Storage batteries, or dry-cell batteries that have a maximum current output greater than 10 amperes, shall be enclosed in effectively locked or sealed housings that are mechanically strong and cover the battery terminals in such a way as to minimize the possibility of completing the battery circuit except by plugging into a suitable receptacle. Recessed live terminals on units of the dry-cell type are permitted if the battery has a maximum current output not greater than 10 amperes and the depth, shape, and position of the recesses are such as to guard against accidental contact and insure disconnection of the battery from the lead wires as soon as the contactors are released by the operator.

The single-shot permissible blasting unit is so designed that the current used cannot ignite gas; the multiple-shot permissible blasting unit is so designed that the current used cannot ignite gas or the time interval of possible arc from the current used is insufficient to ignite gas. The protection afforded is designed principally to avoid dangerous arcing at the face where gas is most likely to be encountered.

Std. 29. Shots should be charged and fired only by authorized persons.

The charging and firing of shots by authorized, competent persons helps to insure proper examination of the holes as to the depth with respect to cut if the coal is cut, freedom of holes from drill cuttings, proper direction of hole, that shots are not fired in the presence of a dangerous quantity of methane, use of safe amount of explosive, use of properly placed stemming, and firing of shots only when all persons are away from the vicinity of the shot.

"Authorized persons" means qualified shot firers, miners, or other persons the management designates as safe and competent to handle explosives.

Std. 30. Where coal is blasted off the solid in breasts in pitching veins, not more than one-half the face should be blasted at one time, where feasible, so that the face can be approached by way of the opposite manway.

This is self-explanatory and a measure designed to assure a certain degree of safety during approach to the face after blasting. The practice also permits access to the face to remove obstructions to the flow of air should such occur during blasting.

Std. 31. Where coal is blasted off the solid in chambers in comparatively flat veins, where the roof is weak or broken, and where feasible, not more than one-half the face should be blasted at one time, so that examinations can be made from the opposite side.

Similar to standard 30 to assure a safe or reasonably safe path of travel to the face to ascertain conditions exposed by the blast.

Std. 32. Blast holes should be large enough in diameter to permit charging without forcing or ramming.

Friction or impact during forcing or ramming explosives may cause premature detonation. Bit gages should be used by officials, to determine when the drill bits become too worn to drill holes of adequate diameter.

Std. 33. Blast holes should be cleaned properly before the charge is placed in the hole.

This recommendation assists in preventing ramming and assures that the various cartridges of the charge are not separated by fine material which tends to lessen the propagation of detonation from one cartridge to another.

Std. 34. Electric power should be cut off equipment at a face and cut off trailing cables leading to or near the face before explosives are taken to such face, and the electric power should remain off until blasting has been completed.

The protection of the explosive and the detonator from possible electrical arc is an important precaution to reduce the hazard in charging the borehole and in handling explosives at the face. At least one instance is on record of a loaded hole firing prematurely while an electrically powered conveyor was being operated near the face; presumably, the cause was stray current. Also, there is a potential danger of contact of detonator wires or explosives with the ends of power wires or cables which are exposed at defective or inadequately insulated splices.

Std. 35. Each primer should be made up at or near the face where feasible immediately before loading and in a place removed from tracks, trolley wires, power lines, trailing cables, pipe lines, steel ropes, and conveyor pans.

This standard recognizes the safety principle that explosives and detonators should be kept apart until the last possible moment and also the danger of firing primer prematurely from electrical contact or stray current. NOTE—The standards make no recommendation concerning the position of the primer in the borehole; and in general, if any recommendation is made about this practice, it should be that the detonator point toward the bulk of the charge.

Std. 36. A punch of wood or other suitable material should be used to make the hole in the primer cartridge to receive the detonator.

This standard was formulated to mitigate the possible danger of discharge of explosives because of static charges, sparks, or impact during preparation of the explosives cartridge for the

detonator. Wood is the material considered the least likely to cause premature discharge.

Std. 37. Explosives should be adequately stemmed, preferably to the collar of the hole; however, in no instance should the stemming be less than 2 feet in length unless the length of the hole is not sufficient to permit that amount of stemming.

This standard is designed to prevent blown-out shots and the resultant hazard, such as ignition of methane and the starting of fires.

Std. 38. Only wood tamping bars should be used.

Instances have been reported of explosions during tamping with wood bars. Such explosions frequently are attributed to the detonator extending through the side of the primer cartridge or in some way coming in contact with the side of the hole, particularly when the hole is in rock.

Information received from an explosives company indicates that some explosives can be ignited by striking a copper tamping bar against rock, by brass against brass, brass against rock, bakelite against bakelite, and iron against iron or rock.

Wood tamping bars will not cause sparks that might detonate the explosive.

Std. 39. Leg wires of electric detonators should be kept short-circuited until ready to be connected to cable or blasting line.

The following quotation is from the Du Pont Blasters' Handbook *(18, p. 41)*: "Short-circuiting the wires of electric blasting caps and other electrical firing devices guards against premature firing through accidental contact between the wires and an electric current. The use of short-circuited devices is an extremely important safety measure in any operation where stray currents may exist, or where there is a possibility of contact between the ends of the wires and electrically charged rails, pipes, or machinery."

Std. 40. A blasting cable or blasting line should be:

**a.* Long enough to permit the miner to fire from a place of safety which is out of line of the blast by at least one 90° turn.

**b.* Broken and short-circuited a safe distance from the face and kept short-circuited at the battery end until ready to attach to the blasting unit.

c. Staggered as to length at the detonator end to prevent short-circuiting.

d. Wound up after each shot or adequately supported on insulators.

e. Kept away from track, power wires, pipe lines, and other possible sources of active or stray currents.

a. Numerous instances have been recorded where men have been killed by flying material because the blasting cable or line was not long enough to permit firing from a safe place, preferably around a 90° turn from the line of fire.

b. The following quotation is from the Du Pont Blasters' Handbook *(18, p. 159)*: "Probably the most important precau-

tions (against stray currents firing detonators) are keeping the leg wires of electric detonators and squibs short-circuited until the moment of connecting them in the blasting circuit, and *keeping the leading wires short-circuited until the moment of connecting them to the source of current.*"

c. Staggering blasting cables "as to length at the detonator end" is to minimize the possibility of bare ends of either blasting lines or detonator wires touching one another inadvertently and thus causing misfires.

d. The adequate support or winding up of blasting cables or lines serves a twofold purpose; it lessens the possibility of stray-current discharge of shots and decreases the rate of cable wear.

e. This precaution is to decrease the possibility of premature detonation.

Std. 41. Worn places on a blasting cable or a blasting line should be properly insulated as soon as observed.

Bare spots on a blasting cable or line afford a possibility of a short circuit with consequent misfire, or contact may be made with a source of active or stray current.

Std. 42. Separate blasting lines and separate blasting stations should be provided for each working face; blasting stations to be at least 20 feet apart to prevent the possibility of connecting to the wrong line.

This standard is designed to prevent accidental use of the wrong blasting line and possible injury to persons in an adjacent place who might be preparing blasts at the same time.

**Std. 43.* In a gassy mine, examinations for gas should be made before and after blasting, and the place should be examined for fire as soon as practicable after blasting in every mine.

Methane is likely to be liberated by a shot or may be present before shooting. In each case there is always the possibility of gas ignition by a shot, and methane should be removed before blasting. Several large mine fires have been started by small fires that were believed to have been started by blasting. A search for fire after shots are fired would permit prompt extinguishment of a fire.

**Std. 44.* A shot should not be fired in any place where methane can be detected with a permissible flame safety lamp or where more than 1 percent can be detected by a permissible electric methane detector.

Where more than 1 percent of methane is known to be present in the general air in a working place, there are likely to be accumulations in high places in the roof (cavities) and in the kerf. Although permissible explosives are tested in 4 percent methane, they do produce flame and conceivably can ignite an explosive gas-air mixture. Therefore, this standard provides a margin of safety. This standard also agrees with ventilation standard 15–35, which requires that when 1 percent methane

can be detected at the face of a working place the ventilation should be improved.

Std. 45. Only the person who places the charge should remove the shunts and fire the shot.

This prevents blasting accidents attributed to misunderstandings where more than one person is engaged in the blasting operation. One and only one person should make all connections and then fire the shot, thus lessening the possibility of accidental discharges because of improper signals or lapse of memory or excitement.

Std. 46. Shots should be fired promptly after charging.

The possible dangers of accidental discharge of loaded holes while working near the face with tools or from electrical equipment are obvious since the detonator leg wires extend from the hole and may be touched easily.

Std. 47. Before commencing work and also after the firing of every blast, the miner working a breast or any other place in a mine should enter such breast or place to examine and ascertain its condition, and his laborer or assistant should not go to the face of such breast or place until the miner has examined it and found it to be safe.

This standard is designed to prevent unnecessary exposure, especially to persons with possibly limited experience, and also to have someone to summon assistance should an accident occur. Hazards are always increased by the blasting procedure, and extreme care should be exercised until the conditions are ascertained.

**Std. 48.* Ample warning should be given before shots are fired. When two places approach each other closely, the employees of both places should withdraw to safe locations before blasting is done in either place.

Lack of warning frequently causes blasting accidents. Numerous accidents have been recorded where blasts caused injury to persons in adjacent places because of thin separating pillars or lack of careful examination of the pillar especially when driving headings through pillars.

Std. 49. The use of mudcap or other open, unconfined shots should be restricted to battery starting when no gas or fire hazard is present and only when it is otherwise impossible to start the battery; similarly, the use of unconfined "shake" shots in working places and other places in pitching veins may be permitted when necessary to bring down loose hanging coal that is too hazardous to take down by other means. Only permissible explosives should be used for these purposes.

Even permissible explosives when fired in the open are likely to produce enough flame so that gas may be ignited, but a greater measure of safety is afforded when permissible explosives are used. Hazards must be weighed carefully, as in the cases of starting coal at batteries or removing loose material, and the least hazardous practice employed.

Std. 50. A waiting period of at least 15 minutes should elapse before anyone returns to the face when a misfire occurs in instantaneous electric blasting. After such failure, the blasting cable should be disconnected from the source of power and the battery ends short-circuited before electrical connections are examined.

This is believed to be a reasonable time that should elapse after a misfire to prevent the shot firer or any other person from being injured or killed by the delayed firing of a shot. This waiting period was recommended by the majority of Bureau of Mines field employees questioned and is based on actual records of delayed shots as reported from numerous sources.

The short-circuiting precaution is to prevent tampering with the blasting lines and ignition by battery or stray current during the examination to determine the reason for failure.

Std. 51. Misfires should be handled under the supervision of the foreman or his assistant.

The removal of misfired shots is dangerous, and therefore good supervision is needed. Hurry causes many accidents, and a miner may be inclined to take an unnecessary chance to expedite removal of the misfired charge.

Std. 52. Explosives should be removed only by firing a separate charge at least 2 feet away from and parallel with the misfired charge. A careful search should be made to recover the undetonated charge.

Methods of handling misfires are discussed in the Du Pont Blasters' Handbook.

When drilling the hole adjacent to the misfired hole, care should be taken to keep it parallel to and no deeper than the charged hole. The first of these measures is to prevent drilling into and detonating the misfired charge, and the second to minimize the likelihood of undetonated explosive being thrown into the debris from the blast. Special care should be taken, after the new charge is fired, to recover the undetonated charge to prevent later accidents when such explosives are loaded with the coal or during subsequent haulage and preparation.

Std. 53. An accurate record should be kept of the number of misfired shots.

Misfires may be due to faulty blasting practice, defective explosives or detonators, or other cause. A record of misfires will enable the determination of whether an unusual number are occurring and whether corrective measures are necessary.

According to Technical Paper 567 *(37, p. 19)*, misfires should occur no more frequently than 1 for every 5,000 shots.

SECTION 15. VENTILATION

Std. 01. Ventilating fans should be so located that the return air from the mine cannot be drawn into the intake openings.

This standard is self-explanatory. Obviously mine air contains some contaminants and therefore should not be recirculated, which is common where intake- and return-air openings are close together. Recirculation is also abetted by wind direc-

tion in many cases, and the discharge opening of the fan should be pointed away from the intake-air opening if possible.

Std. 02. Main fans should be:

a. Installed on the surface.

**b.* In a fireproof housing. If present installations do not meet this recommendation, such installations should be made fire-resistant.

**c.* Provided with fireproof air ducts. If present ducts do not meet this recommendation, they should be made fire-resistant.

d. Offset from nearest side of mine opening. If a new fan is installed or the present fan is moved, the offset distance should be at least 25 feet.

e. Provided with ample pressure-relief or explosion doors. NOTE: In lieu of provisions *d* and *e*, the fan may be located directly in front of or over a mine opening, provided the opening is not in direct line with possible forces coming out of the mine in the event of an explosion, and provided further that there is another opening having a weak-wall stopping or explosion doors that would be in direct line with the forces coming out of the mine if an explosion occurs, such opening to be not less than 25 or more than 100 feet from the fan opening.

f. Equipped in new installations to permit prompt reversal of air flow.

**g.* Operated continuously, except when the mine is shut down for an extended period.

h. Provided with pressure-recording instruments.

i. Provided with automatic devices to give alarm, unless the fans are constantly attended; and in case of a gassy mine, provision should be made to deenergize, automatically or otherwise, the underground electrical circuits when the fans slow down or stop.

**j.* Inspected daily.

Parts *a, b, c, d, e, f,* and *g* of standard 02 in general correspond with Mine Safety Board Decision 30 *(60)*. This decision is as follows: "In the interest of safety in coal mining, the Bureau of Mines recommends:

"That all active underground coal mines, whether working or idle, have one or more fans in continuous operation. The capacity and installation shall be such that the entire mine workings are adequately ventilated at all times. Main fans shall be located on the surface in fireproof housings offset from the line of any mine opening. The housing shall be provided with ample pressure-relief doors or other devices easily opened by the force of an explosion. The installation shall permit prompt reversal of air flow. For mines that liberate gas, the fan shall have at least two independent sources of power immediately applicable."

a. The installation of main fans underground may present numerous hazards, including the following *(36):*

1. Fire or explosion may make access difficult or dangerous and render the installation inoperative.
2. The fan installation may in itself present a fire hazard.
3. There is likely to be considerable recirculation of air.

4. Reestablishment of mine air circulation is likely to be delayed or difficult in the event of an explosion which damages or destroys the underground fan. This is likely to be true even if there is a well-maintained surface stand-by fan unless this surface fan is adequate to completely ventilate the mine and the coursing of the air is so planned that the direction of air flow will be in no way changed.

5. Heating of a fan motor or fan failure may not be as quickly detected in an underground installation as in a surface installation.

b and *c*. A fire in the fan housing or fan duct may, if the fan is operated blowing, result in the rapid communication of fire to the mine or in large volumes of smoke and gases from the fire being forced into the mine. Destruction of the fan housing or duct would result in interruption of the normal mine ventilation.

Nonfireproof fan housings or ducts might conceivably be made fire-resistant by the use of cement, plaster, adobe, or sheet metal.

d and *e*. A surface fan in direct line of the mine opening and close to that opening is likely to be damaged or destroyed by an explosion, thus greatly handicapping subsequent rescue operations. Where the fan is offset from the direct line of the mine opening and the fan housing or approach has suitable relief by doors or an easily moved roof or walls the fan usually is protected from serious damage and may be placed in operation with little or no delay after an explosion *(60)*.

f. The fan installation should permit prompt reversal of air flow; the direction of air flow should not, however, be changed except upon receipt of a written order from some duly authorized official who has given careful consideration to the probable effects of the change. Some fans are provided with mechanism for the reversal of air flow; in other settings, suitably placed doors in the fan approach and housing are utilized *(60)*.

The following information was supplied by the supervising engineer of the Mine Ventilation Section, Health Division, Bureau of Mines:

The direction of air flow produced by propeller and disk fans can be reversed by reversing the direction of rotation of the fan, as by reversing the leads of the driving motor. The volume of reversed flow usually will be 30 to 70 percent of the normal flow, depending on the design of blades and housing and the presence or absence of guide vanes.

The direction of air flow produced by centrifugal fans must be reversed without reversing the direction of flow through the fan. With surface fans this is accomplished by means of doors or dampers in the side drifts and in the discharge opening (see Montgomery, Theory and Practice of Mine Ventilation, fig. 78, p. 209). In underground installations, reversal of flow is accomplished by doors and special arrangements of airways (see Montgomery, pp. 201-202). Reversed flow volumes are usually (but not necessarily) somewhat less than the normal owing to greater resistance to flow along the reversed-flow path.

The following information was obtained from a fan manufacturer:

"Referring to the operation of a disk fan, your assumption is correct in that the air usually is reversed by changing the direction of rotation of the fan, usually by switching the leads on the motor.

"Referring to the efficiency of the disk fan when it is reversed, I believe it advisable to explain a little further that there are several types of disk fans. The very old type consisted of a rotor being assembled with straight flat plates being used for the blades. With this type fan, it makes no difference in the efficiency of the fan as to which way it rotates.

"The next improvement on this type of fan was accomplished by using a straight steel plate and bending the outer tip of the blade in the direction of rotation. This had the tendency of converting some of the rotating air into linear motion. This type of fan would have a slight reduction probably less than 5 percent in the efficiency when operated in the reversed direction.

"The later type of disk fans are constructed of blades using the air-foil section. This type of fan rotor changes the efficiency materially when operated in the reversed direction. In general, depending upon the air-foil section and the pitch angle setting of the blade, the efficiency would drop from 30 percent to 50 percent when operated in the reverse direction."

Where efficiency is referred to in the above quotation, evidently volume is meant.

g. The recommendation that main fans be operated continuously is intended to apply to both gassy and nongassy mines. The fact that a fan may be shut down for a period of hours, and no explosive or harmful gases found in the mine after the suspension, does not mean that a gas accumulation cannot occur some time under similar circumstances.

The laws of numerous States allow fans at nongassy mines, particularly small mines, to be shut down at the close of the shift and started again at some definite period before the next shift enters the mine.

Standard 15–05 recommends: "If the main fan of a nongassy mine fails or is stopped for more than 30 minutes, the men should be withdrawn from the mine. Before the men reenter the mine after the fan has been started, the mine should be examined thoroughly for gas, and any gas found should be first removed." This standard applies particularly to fan failure, repair of fan, or shut-down of fan for an extended period and is not intended to conflict with standard 15–02*g*. Nevertheless, there may be circumstances in a small, nongassy mine under which it is economically impracticable to carry out a recommendation that the fan be operated continuously. In such cases, recommend that the fan be started and a thorough examination made for gas by a competent official before men enter the mine.

h. All main ventilating fans should be equipped with a pressure-recording gage or water gage to determine the venti-

lating pressure. A recording-gage chart will indicate fan stoppage and changes in ventilating pressure.

i. Any interruption of the ventilation of a gassy mine occasioned by fan stoppage obviously presents a distinct hazard because of the likelihood of gas accumulations. Even a few minutes interruption may result in gas accumulations, particularly in face regions. Prompt deenergizing of electrical circuits, especially in face regions, is necessary. Underground electrical circuits may be deenergized automatically, as described in Information Circular 7262 *(20)*, or a manual system may be formulated for cutting off the mine power quickly. Means should be devised whereby underground hoists may be used to expedite removal of persons to the surface when other underground power lines are deenergized.

Automatic devices to give an alarm when the fan slows or stops are also described in Information Circular 7262 *(20)*.

j. At least daily inspection of a main fan is needed to assure proper maintenance and lubrication.

**Std. 03.* If it is impracticable to install main fans on the surface and if the fans are installed underground, the surroundings of the fans should be fire-resistant. The fans should be operated continuously, and they should be inspected at least twice during each 8-hour period, unless the mine is shut down for an extended period.

In some mines, owing to prior unplanned excavation with no general concern to future operation of the mine, it is impracticable to use a surface fan with any degree of efficiency or without prohibitive expenditure; thus underground fans are the only feasible solution. The surroundings of the fan obviously should be fireproof to prevent the introduction of additional fire hazards. Continuous operation is necessary to mitigate the possibility of gas accumulations. Frequent inspection is necessary to assure proper maintenance and lubrication of the fan.

Std. 04. If the main fan of a gassy mine fails or stops for 5 minutes or more, the men should be withdrawn from the mine immediately. After the fan has been started, the mine should be examined thoroughly for gas, and any gas found should be removed before the men reenter the mine. The same procedure should be followed in a section of a gassy mine if it is dependent on a booster fan.

Instances have been reported of a dangerously gassy condition developing in the face regions of a very gassy mine less than 10 minutes after fan stoppage.

"Should the flow of air be decreased, dangerous gases may accumulate; consequently all sources of ignition should be eliminated, so far as practical; and if the interruption to normal ventilation is continued more than a few minutes, all underground employees should be removed from the mine. When normal ventilation is restored it should be continued at least 2 hours before anyone enters the mine. The mine should then be thoroughly inspected by competent persons and adjudged safe before electric circuits are energized and employees permitted to enter. Serious accidents have occurred through failure to observe these precautions" *(60)*.

Std. 05. If the main fan of a nongassy mine fails or is stopped for more than 30 minutes, the men should be withdrawn from the mine. Before the men reenter the mine after the fan has been started, the mine should be examined thoroughly for gas, and any gas found should be first removed.

Several mine explosions have occurred where the main fan was shut down for several hours and then started for only a short time before the mine power circuits were energized, and men had been allowed to reenter before a thorough examination for inflammable gas had first been made. This practice has caused disasters in mines where previous systematic searches had disclosed less than 0.25 percent methane.

Std. 06. If stoppage of a main fan of a gassy mine is more than momentary, mine electric power should be cut off from face sections; and if stoppage is for 5 minutes or more, power should be cut off from the entire mine. A thorough gas examination should be made before power is restored.

See explanation of standards 15–04 and 15–05.

**Std. 07.* The area around fans should be kept free of dry grass, brush, and rubbish for at least 100 feet in all directions.

This recommendation is made to protect the fan from being destroyed by brush, grass, or rubbish fires in the vicinity of the fan.

Std. 08. A stand-by fan, preferably operated by an internal-combustion or steam engine, should be provided at a gassy mine, when feasible, to serve if the main fan fails.

"Failure to have a stand-by source of power quickly applicable to the main fan in an emergency has resulted in considerable loss of life; the prompt use of a second source of power or of a secondary fan unit has prevented many fatalities. For very gassy mines a separate stand-by fan installation should be provided" *(60)*.

Std. 09. A booster fan should be used only for ventilating a distant extension of a mine if ventilation by improvement of airways is impracticable and if the construction of a new ventilation opening is not feasible. If installed for such reason, the fan motor should be of the enclosed type, the surroundings of the fan fireproofed, and the fan so installed and so located with respect to workings as to reduce possibility of recirculation of air. Where feasible, passage by the fan installation should be by means of an air lock, the doors of which should each have at least 30 square feet cross-sectional area and open automatically when the fan stops operating. Under these conditions standards 15–03–04–05 and 06 apply.

The Bureau of Mines Safety Board discusses booster fans under Decision 4 *(63, p. 11)* as follows:

"The use of a 'booster fan' is rarely justified. In most installations investigated there was recirculation of the air, and where this happens if methane is given off in the circuit there is a corresponding increase in gas content in the air circulated. Explosions have resulted therefrom. The best way, which is ordinarily sufficient, is to improve airways and (or) to install a more powerful surface fan to obtain adequate pressure and

volume of circuits of air throughout the mine. A booster-fan installation should be contemplated for ventilating a distant extension of a mine only where it is not practicable to put down a new shaft and when, after all has been done that is possible to improve the airways, the air pressure required would be so high (exceeding 5 inches water gage) as to prevent proper operation of the underground ventilating doors."

The provisions concerning fireproofing fan surroundings and for enclosed fan motors are designed to minimize fire and explosion hazards.

The provision regarding the passageway around the fan with air lock is to prevent short-circuiting the air.

The provision concerning automatic opening of fan doors and minimum cross-sectional area of doors is to insure some air circulation by the main air current of the area inby the booster fan when the booster fan stops.

**Std. 10.* Auxiliary fans or blowers with tubing should not be used unless approved methods of ventilation are impracticable. When used, they should be installed in intake air and powered with permissible driving units and located to avoid recirculation. The surroundings of the fans should be fire-resistant. The fans should be operated continuously and inspected at least twice during each 8-hour period in a gassy mine, unless the mine is shut down for an extended period.

Mine Safety Board Decision 4 *(63)* is, "In the interest of safety, the United States Bureau of Mines recommends that auxiliary fans or blowers should not be used in coal mines as a substitute for methods of regular and continuous coursing of the air to every face of the mine." A footnote under this decision states: "The only justification for the use of an auxiliary fan in a properly operated coal mine is for emergency work, as in driving a crossheading in rock to make a connection with distant workings, and where it is too far to carry the air properly by a line brattice. In such use, the auxiliary fan should be operated continuously 24 hours in the day, the fan and pipe frequently inspected, and the air in the face of the heading tested. It is safer that the fan be driven by compressed air, but if it is electrically driven the motor and switches should be of explosion-proof type and an armored power conductor employed; especial attention should be given to thorough insulation of the wiring; and the vicinity further should be fireproofed to prevent the possibility of starting a mine fire from electrical breakdown or overheating of bearings."

For use in rock work as discussed above, the Bureau of Mines has approved *(46, p. 12)* the *electrical assembly* of three 1½-horsepower blowers. The approval plate states: "The approval covers the safety of the electrical assembly, and therefore no inference should be drawn from the approval as to the safety of the ventilation practice involving use of this outfit."

The only situation in which the use of auxiliary fans or blowers is not contrary to the Bureau standard recommendation is in the driving of rock tunnels between two coal beds or

through wants or faults. Although the standard mentions tubing, the intent is also to include fans without tubing.

Dangers found by Federal inspectors in the use of auxiliary fans or blowers include intermittent use of fans with the possibility of gas accumulation during stoppage periods, installation of fans so as to recirculate air, installation and wiring of fans such as to present a fire hazard, likelihood of moving gas past open-type electrical equipment and wiring, circulation of air quantities insufficient to provide adequate ventilation, and poor installation and maintenance of tubing. The use of these fans has contributed both indirectly and directly to numerous explosions.

Std. 11. A split ventilating system utilizing air bridges (overcasts or undercasts) should be used instead of doors for conducting ventilation in all passageways where feasible.

Mine Safety Board Decision 29 *(59)* recommends: "2. That wherever practicable the use of doors shall be limited to development openings.

"The Mine Safety Board is of the opinion that the best practice in coal-mine ventilation makes use of a split system employing overcasts or undercasts with doors limited so far as feasible to development openings."

The greater the number of doors used to control the ventilation in a mine, the greater the possibility for leaving a door open, with a resultant interruption of ventilation in some section of the mine. Numerous accumulations of gas and consequent mine explosions are attributed to open doors.

Std. 12. The quantity of air (in cubic feet a minute) in any split, circulated through the last open crosscut, should be at least 200 times the number of men and 500 times the number of haulage animals working in the section and as much more as may be required.

Example: If 70 men and 3 mules were employed in a split of air, this recommendation would require that at least 15,500 cubic feet a minute of air be circulated through the crosscut nearest the face of the most inby point of the split. It is believed that this provision will insure adequate air volume if a large number of persons and animals is employed in a split, particularly since standard 15–13 governs the minimum quantity of air to be conducted in a split.

**Std. 13.* The quantity of air reaching the last open crosscut between any gangway and airway or the maximum inby point of the split should be at least 6,000 cubic feet a minute if practicable.

A minimum of 6,000 cubic feet of air a minute passing the last break-through of an entry is necessary to move the air with enough velocity to obtain adequate change of air and to provide for additional air in the entry in case of an emergency *(79)*.

Standard 15–12, taken in conjunction with this standard, means that more than 6,000 cubic feet a minute is recommended if more than 30 men are employed in a split.

*Std. 14. The quantity of air reaching the face of each working place should be at least 200 cubic feet a minute for each man working in the place and as much more as may be required to dilute, render harmless, and sweep away noxious or dangerous gases.

At least this quantity is necessary to assure air movement at the face, and if gas is present additional air is mandatory to prevent gas accumulation.

Std. 15. Airways should be kept clear to permit free passage of air; this includes nonhaulage air courses as well as those utilized for haulage or man-travel.

This recommendation is advisable to permit unobstructed air flow through the mine and to reduce the cost of air circulation.

Std. 16. The main-intake and main-return air currents in mines should be in separate shafts, slopes, or drifts. It is recognized that some present anthracite mines use the same shaft for intake- and return-air currents and that sinking a new shaft or use of other connection is economically impracticable. In such cases the curtain-wall partition should be wholly of fire-resistant material, of substantial construction, and airtight.

Mine Safety Board Decision 7 *(63, pp. 13-14)* in part is: "In the interest of safety, the United States Bureau of Mines recommends:

"1. That the main intake and main return air currents in mines be in separate shafts, slopes, or drifts."

Discussion of this recommendation states in part:

"Bureau of Mines engineers engaged in mine-recovery operations during or following fires in coal and metal mines have experienced great difficulty in restoring ventilation and coping with hazardous conditions caused by placing the 'intake' and 'return' currents, separated only by a partition, in the same mine opening. Even if the partition is fireproof and remains essentially intact, the smoke and fumes at the bottom of the shaft or slope will work around into both compartments almost inevitably. Also, entrance at the surface to either compartment may be made impossible by flame or smoke.

"If a strong explosion in a coal mine reaches a shaft in which a partition separates the intake and return currents, the partition, even though made of concrete, is sometimes blown out because of the unbalanced explosion pressures in the separate compartments of the shaft."

However, where separate openings are impracticable economically, a fireproof partition mitigates the hazard.

Std. 17. Haulage and hoisting openings and main haulageways should be on pure intake air if feasible. In any event, the air should be known to be safe.

Many lives have been lost during mine fires and following mine explosions because haulage and hoisting openings were not ventilated with intake air. With haulageways in return air, the gas-ignition hazards from electrical equipment are increased greatly. Frequently, smoke, fumes, and gases greatly impede the progress of recovery work along the avenues of easiest and quickest travel after explosions or fires.

Recommendation is made in Mine Safety Board Decision 11 *(63, p. 18)*: "In the interest of safety, the United States Bureau of Mines recommends that in coal mines, haulage and (or) hoisting be kept in intake air so far as possible."

Obviously in many mines, changes placing all haulage and hoisting in intake air would mean changes now impracticable. Nevertheless, the practice of ventilating haulageways with return air involves definite and serious hazards. These hazards may be lessened or, perhaps, are already mitigated by various measures, such as availability of exit ways, ventilated with intake air, maintained in good, travelable condition and known to all employees; the maintenance of good ventilation in all parts of the mine; careful attention to all fire hazards; and an emergency man-hoist in intake air.

Frequent tests of return air that must be conducted through haulageways are invaluable in assuring a measure of safety.

**Std. 18.* The face of any chamber or breast should not be advanced more than 60 feet beyond the nearest open-pillar heading or cross heading.

This standard recommends adequate face ventilation, and connections between intake and return airways must be made at frequent intervals to assure ample face circulation. Such openings also assist men to escape if roof collapses.

Std. 19. Chutes or crosscuts between gangways and airways or headings should be made at intervals sufficient to assure adequate ventilation at the faces but not to exceed 80-foot intervals.

The provisions of the various State mining laws differ widely with respect to the interval between crosscuts or headings. In effect this standard suggests adequate face ventilation, irrespective of crosscut distance and without regard to what the State law may require.

Std. 20. Headings between chambers, breasts, or chutes, except the one nearest the face, should be closed with stoppings, preferably of gob wall, dirt, or tight board.

See discussion of standard 22. Company standards of many coal-mining companies conform with this standard.

Although other types of chamber or breast stoppings are preferable, canvas stoppings should not be condemned if these are well-installed and the faces of chambers or breasts are adequately ventilated. The basic idea is to conduct enough fresh air to the face of every working place to provide a healthful atmosphere for the men therein.

Std. 21. Chambers or breasts should not be worked off any heading, gangway, or roadway in advance of the last crosscut or chute between the gangway and airway, even if line brattices are utilized.

This recommendation is similar to the requirement in the Pennsylvania Bituminous Mining Laws *(77, art. IV, sec. 2, pp. 20-21)* under Duties of Foremen. The following is quoted from the above section: "He (foreman) shall not permit any room or entry to be turned in advance of the ventilating current or

in advance of the last cut-through in the entry, excepting room necks, which may, with the consent of the inspector, be turned by entrymen driving entries." This same rule is observed in the anthracite region and is meant to reduce the possibility of gas accumulation by assuring constant circulation at the face.

Std. 22. Stoppings between intake and return airways should be substantially constructed of incombustible material, except that one temporary stopping of wood may be erected between the last permanent stopping and the last crosscut. Where heavy blasting is done, it may be necessary to erect two temporary stoppings between the last permanent stopping and the last crosscut.

Well-constructed, incombustible stoppings usually are virtually airtight, which is necessary to lessen air leakage and insure efficient ventilation. Incombustible material includes concrete, brick, tile, and stone.

The discussion of Mine Safety Board Decision 9 *(63, pp. 16-17)* contains the following information concerning stoppings:

"The foregoing provisions for continuous circulation of air to the faces presuppose that mining officials obey the mining regulations of the respective State in which the mine under consideration is situated and in addition that they follow the best practices in coal-mine ventilation such as—

"*c.* Erecting stoppings or doors in every crosscut except the one nearest the head of the respective entries or rooms.

"*d.* Employing the best type of stopping which, according to the better State regulations, must be built of incombustible material in crosscuts of the main or more permanent openings.

"The character of stoppings other than in the main-entry crosscuts is not usually specified in the State regulations, but it is good practice to use incombustible material—preferably massive concrete, where possible—for all main stoppings. In room crosscuts, gob walls or dirt filling is usually sufficient if kept tight, or tight board stoppings, preferably gunited or plastered, may be used.

Std. 23. Stoppings should be completed promptly as passageways are advanced.

This is a precautionary measure to insure a sufficient and continual quantity of fresh air at the working face.

Std. 24. Trapdoors placed in stoppings should be so hinged or constructed as to be self-closing, tight, and open against the air current.

This recommendation is designed to minimize leakage at trap doors and assure their closing after opening.

Std. 25. All main doors should have attendants whose constant duty it should be to open them for transportation and travel and prevent them from standing open longer than is necessary for persons or cars to pass through, unless a man precedes trips to open doors and another man follows trips to close doors, or unless a self-acting door is used that is approved by the State mine inspector of the district.

The intent of this recommendation is obvious. Doors are erected to control the ventilating current and unless used as

intended are worthless or even dangerous because dependence upon the operation is created and a false sense of security arises. Self-acting doors have been designed and will function if properly placed and obstructions prevented.

Std. 26. Where doors are used in connection with coursing the air in any one split, or if used in lieu of a split ventilation system, they should be:

**a.* Installed in pairs to form air locks, which should be ventilated sufficiently to insure against an accumulation of gas within the enclosed area.

**b.* Self-closing.

c. Not provided with latches or other devices to hold them open.

d. Set in frames of incombustible material or provided with supplies of rock dust, sand, or chemical extinguishers on each side of doors if the doors are of wood.

e. Hung so that they swing to the clearance side, if feasible.

f. Hung so as to open against the ventilating current.

g. An emergency main door should be provided and kept standing open and so fixed that it can be closed at once if necessary.

Recommendations *a*, *b*, and *c* are designed to prevent short-circuiting of air currents by leaving doors open.

d. Incombustible frames lessen the fire hazard and permit quick repair in the event of damage. If fire-combating materials are available, incipient fires may be extinguished quickly and thus prevent air short circuits.

e. This suggestion is a safety and efficiency measure to prevent employees from coming in contact with trolley or power wires or stumbling on rails and ties. Men should approach the door along the clearance side, and the door should swing to this side so that the traveler may proceed along the walkway side of the gangway.

f. To prevent air leakage; the ventilating pressure tends to close the door and hold it against the frame.

g. An additional safety precaution to assure continuous air circulation or minimize the interruption should a door be damaged.

Std. 27. Line brattice should be:

**a.* Used to conduct the air from the last open crosscut to working faces when necessary to remove gases, explosives fumes, smoke, and dusts.

**b.* Constructed to provide the most adequate air movement possible and convey sufficient ventilation to the face.

Provisions *a* and *b* are designed to assure good ventilation of working faces by conducting the largest possible portion of the available air current to the point where it is most necessary.

Std. 28. The space between the rib and the line brattice should be large enough to permit free flow of air.

A restricted space retards the flow of air, therefore, the largest practicable space should be provided in order that an ample volume may be conducted to the face.

Std. 29. Air bridges should be tightly constructed of incombustible material and of ample area to pass the required quantity of air.

This recommendation is contained in many mining codes; obviously the structure should be substantial and fireproof because usually an entire area depends for ventilation upon the air bridge. A restricted area at an overcast acts as a regulator and tends to reduce the volume flowing through the split.

Std. 30. Where it is not practicable to seal worked-out or abandoned parts of a mine in operation, these worked-out or abandoned parts should be ventilated so far as practicable. Abandoned parts that are accessible should be carefully examined at least once a week by the mine foreman or his assistant. Records of these examinations should be kept.

The ventilation of worked-out or abandoned areas aids in lessening the possibility of gas accumulations. Where it is possible to examine abandoned workings, this should be done to determine the quality of the atmosphere and safeguard against gas liberated in such workings being forced or migrating to live workings unexpectedly. Records place responsibility and tend to avert neglect of duty.

Std. 31. In every sealed fire area, or where water is impounded, one or more stoppings should be fitted with a pipe or valve to allow sampling of the air behind the seals or to provide a means of determining any existing hydrostatic pressure.

The Mining Laws of Indiana *(53, pp. 20-21)* contain detailed provisions concerning the sealing of abandoned or worked-out portions of a mine in which dangerous gases are liberated. One of these provisions relates to the embedding in a seal of a pipe equipped with a valve. The air in every sealed area should be sampled periodically to determine whether quantities of explosive gas have accumulated, whether seals are tight (as may be indicated by low oxygen content), and whether fire exists behind seals (as would be indicated by the presence of carbon monoxide).

The hydrostatic head may also be determined without difficulty through the same sampling pipe.

Std. 32. Ventilation should not be diverted from idle sections to active sections to provide an adequate quantity of air for different working shifts.

Compliance with this recommendation is desirable to avoid accumulations of gas during periods when the flow of air through a section is decreased to augment the quantity in another section. Dangerous conditions may arise quickly if the normal flow of air is interrupted, and any relaxation of good established practice is foolhardy.

**Std. 33.* Working places should not be ventilated by an air current that has passed through abandoned workings or worked-out parts of a mine. If physical conditions are such that ventilation by an air current that has passed through abandoned workings or worked-out parts is necessary, definite measures, such as increased supervision and frequent tests of air, should be made to assure that the air is at all times of good quality and free from a gas-ignition hazard.

Air currents that pass first through abandoned workings or along pillar lines may suddenly, without warning, become contaminated with methane, which may in turn be ignited in the active working sections, causing an explosion. Roof falls in active or abandoned areas may and often do release or force dangerous quantities of methane into the live workings of a mine. Frequent tests of the air will many times avert disaster.

Std. 34. A mine should be classed as gassy when 0.25 percent or more methane or other combustible gas can be detected by a systematic search, or if the mine records establish the fact that methane has been found or ignited.

If the past history of the mine has resulted in its classification as gassy, or if the fire-boss books or other authentic records establish the fact that methane has been found or ignited, the mine should be classed gassy irrespective of the conditions found at the time of inspection. If the mine is classified by the State or company as nongassy but the Federal inspection disclosed the presence of 0.25 percent methane in still air or in an air current, the inspection report should classify the mine as gassy. In the inspection of the mine, a systematic search should be made for methane. Tests should be made in return airways, at faces, in places where the air movement is sluggish, at high points in the roof, on tops of caves, and in accessible old workings. Tests should be made near to but not within machine kerfs, boreholes, or crevices.

To determine percentages of methane as low as 0.25, chemical analyses of air samples should be used. The portable electrically operated methane detector will not determine such small percentages accurately.

If samples collected from sealed areas contain more than 2 percent combustible gas, this fact warrants a gassy rating.

Mine Safety Board Decision 33 *(61)* is: "The Bureau of Mines believes that all coal mines are potentially gassy; for the purpose of administration in the prevention of explosions and fires, the Bureau recommends:

"That any coal mine wherein methane or other combustible gas can be detected in amounts as much as 0.25 of 1 percent or more by frequent systematic searches shall be classified as a gassy mine."

**Std. 35.* If inflammable gas can be detected in the air of a working place with a flame safety lamp, or if it contains more than 1 percent inflammable gas as determined by an electric methane detector or by chemical analysis, the ventilation should be improved immediately. If air in the working place contains more than 2 percent inflammable gas (slightly less than ½-inch cap on a testing or low flame of a flame safety lamp), the workers should be withdrawn until the ventilation is improved. By "air of a working place" is meant air not nearer than 1 foot from the face. Air should be tested for gas at such points as conditions may warrant.

This standard, recommending definite limitations on the quantity of inflammable gas in working places, is designed to prevent gas ignitions and mine explosions. If the provisions

of the recommendation are strictly followed there should be a *good* factor of safety against explosions. This standard requires a greater factor of safety than Mine Safety Board Decision 9. Some coal companies have adopted and rigidly enforce a 1-percent methane limitation in return airways. The 1-foot distance is set arbitrarily to prevent the reporting of erroneous information obtained when tests are made in pockets or crevices where undoubtedly the prevailing atmosphere is not representative of the general quality of the air in a working place.

**Std. 36.* If the air immediately returning from a split that ventilates any group of active workings contains more than one-half of 1 percent of inflammable gas, as determined by chemical analyses in duplicate or by other recognized means of accurate detection, the ventilation should be improved immediately if at all possible. If this air contains more than 1½ percent inflammable gas, the workers should be withdrawn until ventilation has been improved.

The second part of this recommendation corresponds with provision 6 of Mine Safety Board Decision 9 *(63, pp. 16-17)*. The first part of the standard gives what is considered a desirable limit for the percent of methane in the return air current from a split which ventilates any group of active workings. The figure 0.5 percent of inflammable gas has been selected from past experience as the proper limit beyond which the workings of that split should be considered hazardous, requiring improved ventilation. This figure (½ percent) provides a factor of safety so that ventilation may be improved before a dangerous situation develops.

**Std. 37.* At least two permissible flame safety lamps should be kept in proper working condition at every coal mine, and at least two persons should be kept well-informed as to the safe maintenance and use of flame safety lamps.

In Mine Safety Board Decision 1 *(62)* the recommendations are made that:

"3. Any employee before being supplied with a permissible flame safety lamp be examined by a competent official of the mine to assure the man's ability to detect gas; and

"4. All coal mines whether classed as nongassy or gassy in any part be supplied with magnetically locked, permissible, flame safety lamps, properly maintained and in sufficient number for all inspection purposes."

The Bureau of Mines believes that all coal mines are potentially gassy, since gas has been found in mines that for years had been considered nongassy. Many gas ignitions and explosions have occurred in so-called nongassy mines. Recommendation is therefore made that every coal mine, including nongassy mines, be equipped with permissible flame safety lamps and that a minimum of two of the mine personnel be familiar with the use, maintenance, and limitations of the lamps. Two lamps are required so that a spare is available in case of necessity.

Std. 38. Only permissible methane detectors should be used for making inspections for explosive gas. (Permissible flame safety lamps are considered a type of permissible methane detector.)

Bureau of Mines tests have shown that some nonpermissible types of flame safety lamps can under some circumstances ignite methane. Also, several mine explosions are attributed to disassembling a nonpermissible flame safety lamp to relight it.

Std. 39. All men required to use methane detectors and permissible flame safety lamps should be thoroughly instructed in their use and limitations.

With respect to limitations of electrically operated methane detectors, no portable, electrically operated methane detector is infallible; none should be used as a basis for an important decision or recommendation without checking with a second detector or with laboratory analyses of samples taken at the same time and place. Thorough knowledge of the principles involved, as well as the technique to be employed, is necessary to avoid erroneous findings.

Std. 40. All underground officials whose duties are to test for gas should wear corrective-lens glasses if necessary for good vision.

Good vision is necessary to detect small percentages of gas with a flame safety lamp because even with the best of vision small percentages are questionable owing to the faint, evasive color of an incipient gas cap and the possibility of a hazy, indistinctly colored flame existent above the luminous flame when some fuels are used.

Std. 41. Enough assistant foremen should be employed in gassy mines; they should:

- **a.* Begin examination of the mine not more than 3 hours before each shift enters the mine.
- **b.* Examine every working place, all places adjacent to live workings, every roadway and travel way, every unfenced road to abandoned workings, and all accessible falls adjacent to live workings for explosive gas and other hazards.
- **c.* Leave at or near the face of each place examined their initials and the dates.
- **d.* Place a danger sign across the entrance to every place where a dangerous condition is found. The danger sign should be removed only by a certified official after the danger has been removed.
- **e.* Report to a proper official on the surface or at designated underground stations any dangers found before the men enter the mine or pass such designated stations.
- **f.* Record in ink the results of their inspections in a book kept on the surface for that purpose. Similar records also should be kept at designated underground stations.

With too few assistant foremen or other certified persons competent to thoroughly examine and adjudge conditions with a measure of accuracy, examinations for gas and other hazards are likely to be hurried and incomplete. The various parts of this recommendation are predicated upon sound premises deemed necessary to safeguard employees, secure thorough inspections at proper times and acceptance of responsibility by signed records, and obtain accurate information on existing con-

ditions. The laws of virtually all coal-mining States contain similar requirements.

Std. 42. All coal mines classed as nongassy should be carefully inspected for methane at least once a month; a record should be kept of the inspection.

Because a mine has been classed nongassy does not mean that it will necessarily continue to be nongassy; therefore, all coal mines should be considered as potentially gassy. Frequent inspections assure a measure of safety not otherwise afforded until a distressing situation arises. Records establish responsibility and tend to curb carelessness and neglect.

**Std. 43.* The mine foreman or his designated assistant on *each shift* should read and countersign the assistant foreman's reports of examination preliminary to that shift before the men enter the mine or pass designated underground stations. (The preshift assistant foreman is the mine foreman's designated assistant.) The mine foreman should read and countersign the assistant foreman's reports daily.

This recommendation is to insure that the mine foreman or a responsible person acting for him is kept informed of conditions so that prompt action may be taken to correct hazards and avoid accidents.

Std. 44. Air in working places or traveling ways should contain at least 20 percent oxygen and not more than 0.5 percent carbon dioxide, as determined by chemical analysis, and no harmful amount of dust or poisonous gas.

This recommendation is fundamental for a healthful atmosphere. Good ventilation in coal mines automatically provides air of this or even better quality. Mine Safety Board Decision 9 in part recommends "The air in any unsealed place shall be considered unfit for men if it shall be found to contain less than 19 percent oxygen (dry basis), more than 1 percent carbon dioxide, or a harmful amount of poisonous gas. In adequately ventilated mines, little difficulty will be experienced in meeting this requirement."

Std. 45. Changes in ventilation which may affect the safety of the men should be made when the mine is idle and with no men in the mine other than those engaged in changing the ventilation.

Changes in ventilation may develop serious and unexpected hazards respective to inflammable gas accumulation, and the least possible number of men should be exposed to any hazard.

Std. 46. Accumulations of gas should be removed under the direct supervision of a foreman or other competent official, and no men should be permitted to work, or electric equipment be operated, on the return of the split while gas is being removed.

The hazards involved when this recommendation is not followed seem obvious, yet mine explosions have occurred because sufficient precautions were not taken when accumulations of gas are moved. All power should be cut off every section of a mine during ventilation changes if there is any possibility of

the change affecting a section other than the one or ones in which the changes are contemplated.

Std. 47. Air measurements should be made by the mine foreman, his assistants, or other certified officials at least once each week at or near the mouth of the main intake and return of the mine and also in or immediately adjacent to the last crosscut on each air split, at or near the face of each airway or gangway, and at the nearest cross heading or crosscut to the face of the inside and outside chamber, breast, or chute where men are employed. Tests should be made with a permissible flame safety lamp or other methane indicator in such splits and in the main return. Records of these measurements and tests should be kept in a book furnished for this purpose.

The provisions of this standard are designed to assist in insuring good mine ventilation. Frequent tests tend to prevent negligence on the part of those responsible for the conduction of the air, and records place definite responsibility especially when signatures are appended.

SECTION 16. SURFACE HAULAGE

Std. 01. Track and roadbed should be maintained in good condition.

Good track and roadbed are necessary for efficient, safe haulage. The track should be ballasted properly to prevent movement, and drainage is essential to maintain a uniformly elevated firm roadbed. Crushed stone or gravel are ideal materials for ballast; although the first cost is comparatively high, the ultimate benefit usually will justify the expenditure *(41, p. 2)*.

**Std. 02.* There should be a clearance of 30 inches or more on at least one side of the tracks, but if it is not practicable to obtain such clearance at some places, these places should be marked with signs warning of restricted clearance.

Required by many State mining laws and company safety rules. Discretion must be used in the application of this standard because the condition of the haulageways, haulage speed, type of equipment, number of persons traveling, and economic feasibility must be considered when definite recommendations are made concerning clearance. Warning signs are inexpensive and certainly necessary where other measures are not practicable. Mine Safety Board Decision 14 *(63, p. 24)* refers to clearance.

Std. 03. Frogs, guard rails, and lead rails should be blocked if there is danger of persons catching their feet in them.

This safety measure *(41, p. 2)* was evolved to prevent haulage accidents resulting from feet being caught in narrow places at switches; it is especially important where speedy haulage is necessary owing to lack of proper equipment, long hauls, etc. Blocking is relatively inexpensive, and many coal companies have adopted this practice.

Std. 04. Track switches should be complete with throws and bridle bars.

All switches should be equipped with switch stands or throws, particularly in mines where mechanical haulage is employed. Loose switch points or latches that are kicked into position by the haulage crew while on moving cars or locomotives have caused many accidents and should not be used if safety is considered. No means is provided to hold these latches in position, and they often spring open as the wheels pass over them, causing derailments and wrecks, with consequent accidents to workers as well as delays in work and breakage of equipment *(41, p. 3)*.

Std. 05. Switch throws should be so installed as to provide adequate clearance for switchmen.

This precaution is necessary to provide protection for trip riders or brakemen who, often after manipulating a switch, are required to wait until the entire train has passed to reset the switch.

Std. 06. The rod extending from the bridle bar to the throw should be covered or the stumbling hazard otherwise minimized.

"All stumbling hazards at switch throws should be eliminated" *(41, p. 3)*.

Std. 07. Where surface operations require that many persons pass over the haulageway, a warning signal should be installed or an overhead walkway or underpass provided.

This requirement is self-explanatory.

Std. 08. All track crossings should be provided with warning signs.
Std. 09. Crossings on the surface should be guarded while cars are being moved.

These standards are designed to reduce the number of accidents occurring when persons are required to cross tracks when equipment is in motion. Inattention, a temporary lapse of memory, and chance taking, as well as physical defects, such as impaired hearing and eyesight, contribute to numerous accidents at crossings. Warning signs and crossing guards have lessened the frequency rate of these accidents; however, impulsive and careless persons still frequently defy warnings.

Std. 10. Derail devices should be installed where necessary on all sidetracks on the surface near junctions with main lines.

Derails prevent run-away cars or trains from entering main-line tracks and causing wrecks, which in many cases are expensive both in toll of lives and in equipment demolished.

**Std. 11.* Outside planes or inclines should have:
a. Positive stopblocks at the top.
b. Derails near the top.
c. Derails near the bottom.

These precautions are designed to stop or deflect uncontrolled cars or trains so that persons will not be injured if rope, hitching, or other equipment fails, or if cars are carelessly detached from ropes at points where they cannot be controlled.

Std. 12. In handling railroad cars, brakemen should:
a. Use suitable brake sticks, preferably made of metal.
b. Use safety belts where practicable.
c. Wear safety hats.
d. Use railroad-type pinch bars for starting cars.
e. Wear snug-fitting clothing.

a. Records show that brake-stick failure has resulted in accidents, especially where a light wood stick was used.

b. Good safety regulations require the wearing of safety belts when hazardous work is performed, such as handling railroad cars, working on a moving platform, or doing other work requiring the use of both hands, and at an elevation of 10 feet or more above the ground. Safety belts worn by car droppers usually are fastened to the upper rung of the steel ladder near the brake wheel; this permits freedom of movement while the brake mechanism is operated and gives protection against falling if the car moves quickly or stops suddenly.

c. A study conducted by the Bureau of Mines in a group of seven coal mines showed that the accident frequency of head injuries was reduced by 75 percent and likewise the accident severity rate by 96 percent *(16, p. 14)*. This undoubtedly proves the worth of protective headgear.

d. A special pinch bar is recommended for this work by the safe-practice guide for Railroads in Industrial Plants, a publication by the National Safety Council.

e. Loose clothing is dangerous when a man is working around moving machinery, owing to possible entangling with projections or moving parts, resulting in severe injuries before he could be extricated *(16, p. 4)*.

SECTION 17. UNDERGROUND HAULAGE

Std. 01. Haulage roads should be kept free of coal spillage and debris.

Clean haulage roads are a basic requirement for safe, efficient haulage. Where haulage employees' movements are hampered, accidents usually result. Cleanliness is a prerequisite for safety.

Std. 02. The roadbed should be kept well drained and surfaced.

The presence of water adds to the difficulties of maintaining track and surfacing prevents track movement and consequent misalinement.

Std. 03. Rails should be of sufficient weight to carry safely the heaviest rolling stock, and they should be attached firmly to ties that are of adequate size and properly spaced.

The track should be laid with rails and ties of sufficient size and quality to carry the maximum load required without rail distortion or tie failure. Inferior grade or undersize materials increase the maintenance necessary to have *good,* safe track.

Std. 04. On all haulage roads, rails should be connected at the joints by angle bars or plates, or they should be welded.

This provision is necessary to prevent lipped joints, possible open joints, and shifting of rails, with consequent misalinement. Good track is essential to safe haulage.

Std. 05. The track should be properly alined and free from high or low joints, broken rails, defective switches, defective frogs, and improperly alined frogs.

Obviously any track defect is a hazard that eventually may cause a wreck and severe injuries to haulagemen or possibly many men if a man-trip is wrecked.

Std. 06. Frogs, guard rails, and lead rails should be blocked if there is danger of persons catching their feet in them.

All frogs and switch points should be blocked to prevent employees from getting their feet caught in them. Blocking lessens the possibility that trip riders may run ahead of a train, become entangled in a switch, and be run over before the motorman can stop the train *(41, p. 2)*.

Std. 07. Track switches should be complete with throws and bridle bars.

See standard 04, section 16.

Std. 08. The rod extending from the bridle bar to the throw should be covered or the stumbling hazard otherwise minimized.

See standard 06, section 16.

Std. 09. Switch throws should be placed on the clearance side, preferably in shelter holes.

Switch throws should be placed as far from the track as possible, preferably in a recess in the rib *(41, p. 3)* so that the switchman will be protected from possible derailed equipment.

Std. 10. Main switches on haulageways should be illuminated with electric lights; however, in gassy mines these lights should not be installed within 150 feet of the end of pillar workings or any open, partly caved, poorly ventilated places unless they are of the permissible type.

Proper illumination aids greatly in preventing accidents, especially underground where restricted space quite often prevails and obstructions are numerous. Even the best light provides limited illumination owing to the light-absorption qualities of dark surfaces or rather the lack of reflective qualities *(41, p. 5)*.

The hazard of using incandescent lights or similar lights lacking protective features is the possibility of igniting gas when the light is broken or impaired.

The light is in most instances a marker or warning at a switch or sidetrack since generalized illumination of haulageways is unusual.

**Std. 11.* Where practicable, there should be a continuous clearance on one side from the mine portals to all working faces of at least 30 inches from the nearest obstruction to the farthest projection of moving equipment.

A free, unobstructed walkway space permits unhampered travel, lessens stumbling hazards incident to even good track

installations, and minimizes the danger of employees being injured by haulage equipment *(63, p. 24)*.

Where natural conditions permit, it is desirable to drive haulageways wide enough to allow ample clearance along both sides of the track. Where this is not possible (and quite often it is not possible), a continuous free space should be provided along one side of the track, and the walkway should be along the side opposite from trolley and power wires. Frequently clearance space is absent because of careless, haphazard gangway development. Even where space is provided, quite often timbers are set improperly and areas are restricted. If at all feasible (and the practicability can best be determined when all the factors are known) minimum (30-inch) clearance standards should be established and rigidly enforced.

**Std. 12.* Clearance should not be obstructed by loose rock or coal, supplies, or other material.

Obstructed clearance is practically as hazardous as the lack of clearance; frequently the clearance space is utilized for the storage of supplies or refuse and the safety value of the space is destroyed *(41, p. 4)*.

Std. 13. At sidetracks there should be a clearance of at least 30 inches between the farthest projection of equipment on any two tracks.

Numerous accidents resulting in fatal and serious nonfatal injuries have occurred because of failure to allow enough clearance space between tracks at partings and sidetracks. A light or marker installed at the junction of tracks to indicate the minimum allowable clearance has prevented many accidents caused by improper storage at intersections. Serious injuries may be in most cases avoided by thoughtfulness, and reminders in the form of warnings aid in developing careful employees. In many instances congested areas can be avoided merely by planning before excavation *(41, p. 4)*.

Std. 14. Shelter holes should be:

**a*. Provided along all haulageways if used as traveling ways.
b. Suitably marked.
c. On the clearance side where practicable.
d. Not more than 150 feet apart. (Chamber, breast, or chute necks, and crosscuts or breakthroughs, if on the clearance side, may be considered as shelter holes.)
e. Provided at all switch throws where sufficient clearance is not available.
f. Provided on both sides of all doors where sufficient clearance is not available.
g. Kept clean and free of obstruction.

a and *b*. Recommended in Mine Safety Board Decision 14 *(63, p. 24)*. Places of refuge are essential to avert injuries to persons traveling haulageways, especially if equipment is derailed. "Suitably marked" is required so that the shelter holes are easily found in an emergency.

c. This recommendation is designed to prevent movement of persons under the trolley wire and to encourage the use of a regular walkway side or clearance space *(41, p. 5)*.

d. This standard agrees with the Pennsylvania Anthracite Mining Laws in many respects. The interval recommended is great owing to the difficulty and cost entailed in making shelter holes along rock gangways in the anthracite field.

e. For the protection of the switchman or trip rider from derailed equipment.

f. Required for the protection of persons approaching or near doors when trips are passing.

g. The protection feature is eliminated when the size is reduced by partly filling the space with refuse or debris *(41, p. 5)*.

Std. 15. Safety holes, adequate for man shelter, should be provided in safe locations at landings of slopes and planes and should be kept free of obstructions.

This standard is to protect slope tenders or "hookers-on" from possible run-away cars and from material that might fall off cars and roll down the slope or plane. Required by most State mining codes and company safety rules.

**Std. 16.* Short pieces of rail, ties, or props should not be used to raise or slue derailed cars and locomotives, or for pushing cars or trips.

Rerailing cars or equipment is hazardous work, and makeshift devices only increase the hazard. Comparatively safe devices and methods have been devised for this work, and these should be employed.

**Std. 17.* Locomotives should be equipped with suitable rerailers, jacks, and other necessary tools for rerailing cars or locomotives.

Proper tools are essential to avoid unnecessary risks while hazardous work is performed *(41, pp. 9-10)*.

Std. 18. If necessary, guards should be installed in the cabs of locomotives, and safety chains or other suitable devices should be provided to prevent motors from falling to the floor or pushing through the tops of locomotives.

Sometimes gears or cables are exposed in the cabs of locomotives owing to a lack of forethought when the machine was designed or the carelessness of some person in not replacing a guard or shield after repairing the equipment. *Both* unguarded gears and unshielded cables are hazards to locomotive operators, and proper guards or shields should be installed. Safety chains or devices are a safety precaution to lessen the hazard if motor support fails.

Std. 19. Insulating mats should be provided for the floor and seat of the locomotive cab.

These provisions are designed to lessen the shock hazards common to electric equipment by preventing the operator from contact with metal parts.

Std. 20. Internal-combustion engines or steam locomotives should not be used underground.

NOTE.—A schedule for testing Diesel-powered locomotives (Schedule 22) for use in underground mines was approved on September 2, 1944, which permits their use underground.

Internal-combustion engines emit poisonous gases in the exhaust fumes which are *undesirable* atmospheric contaminants *(63, p. 28)*. Steam locomotives are a fire hazard and gas-ignition hazard *(63, p. 29)*. Internal-combustion engines may also ignite methane.

Std. 21. Where two or more locomotives or other self-propelled track-mounted equipment is operated independently on the same track, a block-signal system or telephones should be used to control their movement.

In larger mines, where haulage is partly or wholly mechanical, a block-signal system should be used. This system may be automatic or partly manually operated as the need requires. Dispatchers control movement of equipment by telephone in many large mines *(41, p. 8)*. Some method is necessary to avoid wrecks and expedite movement.

Std. 22. Self-propelled track-mounted equipment, including locomotives, cutting machines, and loaders, should be handled carefully and kept under control at all times. Locomotives should be provided with efficient headlights and warning devices. When equipment without headlights is moved into or out of a working place, it should be stopped at any intersection or curve and be preceded by a helper or flagman.

This recommendation is made to help prevent haulage accidents, which rank second in the causes of loss of life and injuries in coal mines.

The efficiency of headlights and warning devices for various types of equipment cannot be determined on the basis of any standard size or construction.

The headlights should be substantially constructed to withstand mechanical shock during use; the headlight bulbs should not be supported by waste or other combustible material, as such practices introduce a fire-ignition hazard that is dangerous in coal mines. Locomotives should have polished headlight reflectors so that a concentrated beam of light is directed along the haulageway. In general, headlights on mining and loading machines are for short-range lighting, and diffusing reflectors are adequate *(42, p. 6)*.

Warning devices, such as bells and gongs, are especially desirable if persons with impaired vision are employed. Instances have been reported where a person failed to see a warning sign or light because of concentration, worry, or other absorbing mental influence.

Std. 23. Underground hoists should be equipped with brakes adequate for the required service.

Brakes capable of holding the maximum load on the steepest part of the grade are necessary in the event of power failure.

Brakes that are applied automatically may not be practicable from an economic standpoint unless men are handled.

Std. 24. If underground hoists are used for handling men:

**a.* An accurate indicator of the trip position should be so placed as to be in constant view of the hoistman.

**b.* A second hoistman should be in attendance at all times while a man-trip is being hoisted or lowered, unless the hoist is equipped with automatic overwind, overspeed, and stop controls.

**c.* No rope should be used which shows more than six broken wires in any single pitch length or lay, or when the wires in the crown of a strand are worn to less than 65 percent of their original diameter, or when inspection indicates a dangerous amount of corrosion or distortion.

d. Signal codes should be posted in the hoist room and at other places where signals are regularly given.

a. See explanation of standard 04–06.

b. See explanation of standard 04–03.

c. See explanation of standard 04–14.

d. See explanation of standard 04–20.

Std. 25. Ropes should be of adequate size and strength for the required service.

See explanation of standard 04–10.

**Std. 26.* Ropes should be replaced as soon as there is evidence of undue weakness or other conditions which indicate that the rope may fail.

Self-explanatory.

**Std. 27.* Man-trips or man-cars on mechanical or gravity slopes or inclines should be provided with safety ropes or chains connected to the main ropes at points above the regular hitching, and extending around or through all cars. In addition, it is desirable that they be provided with mechanical devices to stop the cars or trips if the main ropes, couplings, or drawbars fail.

This recommendation is made to provide two safeguards, which should be used when man-trips are operated on mechanical or gravity planes or inclines. If the main-rope coupling to the trip should break or become detached inadvertently or if the rope or cone fails near the coupling, a secondary attachment would be afforded. This attachment would prevent a run-away trip that would endanger the lives of workmen riding in the man-trip. If the rope should break beyond the connection point of the safety attachment, a positive mechanical device would be necessary to stop the trip.

Std. 28. Ropes, links, chains, and rope sockets should be examined carefully at least every 24 hours by a competent person.

See explanation of standard 04–16.

Std. 29. Drum guides or flanges should be high enough to keep the rope from slipping off the ends of the drum.

See explanation of standard 04–07.

Std. 30. The rope end should be secured to the drum; it should make one full lap around the drum shaft or a spoke of the drum and be secured by clamps or clips.

See explanation of standard 04–11.

Std. 31. The rope should be fastened to its load by a socket filled with suitable metal, or by a thimble and clamps or clips.

See explanation of standard 04–12.

Std. 32. Haulage equipment should be maintained in a safe condition.

Good maintenance is essential to both safety and efficiency *(73, p. 5)*. A defective machine is a hazard.

**Std. 33.* Sprags, chains, or car blocks should be used on all standing cars, regardless of the grade. If cars have brakes, they should be set. The use of chips or small pieces of coal or rock, or similar makeshifts, should not be considered as adequate blocking.

Failure to block cars properly has resulted in many injuries and fatalities, particularly where the place is either going to the dip or the rise. Derail switches, automatic or otherwise, should be installed in steep inclines. The type of equipment and the natural condition of the place must be considered when determining the most suitable car block or securing device to use. Numerous devices are used, such as chains *(41, p. 7)*, clevises, crossed timbers *(73, p. 6)*, scotches, and sprags, and judgment must be exercised in the selection *(41, p. 8)*.

Std. 34. Effective drags or equivalent positive mechanical devices should be used on rope trips on ascending grades.

When cars are hauled up long grades by rope or locomotive, a drag should be attached to the last car to prevent run-away cars should a coupling or hitching break *(41, p. 7)*.

Std. 35. On all inside slopes and planes having knuckles, there should be positive-action safety blocks at or above the knuckles.

This measure is necessary to prevent injuries to persons, who may have occasion to travel slopes, by run-away cars and is good safety practice. A securely fastened, movable head block is effective.

Std. 36. In gangways that rise at and near the faces, standing cars should be securely blocked, and stopblocks or derails should be placed between the cars at or near the face and the first outby chute or other loading places.

This is to prevent run-away cars from entering the gangway track and endangering persons employed there or at the adjacent chute *(34)* or chamber.

Std. 37. Workmen driving places to the dip should be protected by positive stopblocks or derails at the top and positive derails placed at safe distances from the faces. If cars are being loaded or are standing at or near the faces of pitching places, they should be securely held by chains, properly placed blocks, sprags, or clevises *(73, p. 6)*. (Note to inspector: The effectiveness of the method used should be carefully observed.)

This standard is designed to prevent injuries from run-away cars to persons employed at the face of dip places.

A substantial head block suspended from a firmly set, adequate-size anchor prop is an effective stop block and remains in position unless moved to the clear.

**Std. 38.* Cars placed for loading in chambers, faces of gangways, and other working places should be effectively blocked. (Note to inspector: The effectiveness of the method of blocking cars under various conditions should be carefully observed.)

Numerous accidents have been caused by cars accidentally moved in some manner at the working face and each car should be securely blocked. The type of blocking required depends largely upon the existing track grade and type of car, and care should be exercised to assure that effective securing devices are used at all times.

**Std. 39.* Effective methods should be used to control cars while being loaded at chutes and other loading places. (Note to inspector: The effectiveness of the method used should be carefully observed.)

Run-away cars are prevalent where the loading track is inclined, and some reliable method of control should be used to prevent such occurrences. If braces are used, a car block or sprag should also be placed as additional assurance.

Std. 40. Slides or skids should be used on descending grades where the locomotive is not adequate to control the trip.

This is good practice *(34, p. 11, fig. 13)* and a precautionary measure.

Std. 41. Locomotive headlights should be maintained in good repair.

Good illumination is a prerequisite for safe operation of machinery.

**Std. 42.* Efficient electric trip lights should be used on the rear of all trips and on the front of locomotive-pushed trips. Permissible trip lights should be used in gassy mines. Reflector buttons should not be substituted for trip lights.

Many mining companies have adopted the trip light and enforce its use. Permissible trip lights are designed for the purpose and will not, if properly maintained, ignite methane *(42, p. 9)*.

Reflector buttons can only be seen when reflecting light *(41, p. 9)*.

Std. 43. Animals working underground should be provided with permissible electric lights.

This recommendation is made to give the animal light, so that he can see where he is traveling, to prevent injury to men by the animal stumbling or falling, to prevent other trips from running into or being pushed into the animal, and to prevent the animal from running into obstructions along the haulageway.

Std. 44. Pushing of cars or trips by locomotives should be eliminated so far as possible.

This safety rule is enforced by most of the progressive coal-mining companies. A motorman pushing a trip has limited vision, which makes it difficult for him to control the end of the trip and locate accurately doors, switches, and turn-outs.

**Std. 45.* Only authorized persons should operate locomotives.

This provision is necessary to prevent unqualified or irresponsible persons from jeopardizing their own lives as well as the lives of others by operating machinery with which they are not familiar.

**Std. 46.* Riding on locomotives should be prohibited except to those operating the trip and persons authorized by the management.

Only members of haulage crews should be permitted to ride on haulage locomotives, except in emergency or by special authority of the mine foreman. Anyone riding by such authority should be required to sit in the cab and not on top of the locomotive. To make this rule effective, it must apply to mine officials as well as employees.

Many men have been severely injured by falling off locomotives while riding on top, owing to a sudden lurch of the train while going around sharp curves or to derailment or coming in contact with a low place in the roof or a low timber *(41, p. 14)*.

**Std. 47.* Riding on top of loaded cars, between cars, on the outside of cars, or on bumpers on front of cars should be prohibited. This does not apply to mule-hauled trips where car-brake levers are on the front end of the cars.

This standard is designed to reduce the number of haulage accidents occurring each year. Many brakemen or trip riders are squeezed between the tops of loaded cars and the roof or timbers, fall between cars, or are caught between the sides of cars and timbers because of hazardous riding practices.

Std. 48. Motormen or brakemen should not get on or off cars or trips in motion.

Jumping off a moving trip or locomotive and running ahead to throw a switch or open a door is dangerous, yet very common practice; the practice is especially common and dangerous in slope haulage. Little time is saved and there is always the possibility that the person will stumble or miss his footing and be injured or killed before the trip can be stopped *(41, p. 12)*.

**Std. 49.* When the motorman leaves a locomotive, even temporarily, the reverse lever of the control should be set at neutral and the brake set tightly; if the lever is removable, it should be carried by the motorman.

This standard is to prevent unauthorized tampering with or accidental movement of locomotives.

**Std. 50.* Back-poling should be allowed only at places where the trolley pole cannot be reversed and when the locomotive is operated at a very low speed.

If the trolley pole should jump off the wire while being operated in this position, it is possible that a timber may be dis-

lodged or the pole broken and either timber or pole hit the motorman. Many persons have been injured by various occurrences connected with back-poling *(41, p. 12)*.

**Std. 51.* Sliding the cable "nip" along the wire should be prohibited.

Sliding the cable "nip" along the wire usually produces arcs which are gas-ignition hazards. The arcs are also hazardous to the eyes of the person holding the "nip." Cables or nips may become entangled in projections and injure the holder in being severed. Arcs weaken trolley wire, and the arcs in the controller produced by "pointing" burn fingers and segments. Hook nips are especially hazardous because the hook may become fouled and the person holding the nip be injured by dislodgement of wire, timbers, or mine roof.

**Std. 52.* Flying switches should be prohibited.

Derailments are common from this practice and result in damage to switches, turn-outs and cars. High speed is required, and the locomotive is often out of control when flying switches are made.

Std. 53. At least one car should be placed between the locomotive and cars or trucks carrying rails or long timbers.

This is good safety practice to protect the motorman in case of derailment, wreck, or the shifting of rails or timbers because of sudden stops or change of direction at curves.

Std. 54. Intervals of at least 500 feet should be maintained between all "light" locomotives and all locomotive trips traveling in the same direction, and the locomotives should be held to a low speed.

The interval and speed regulations are necessary precautions to allow the preceding motorman time to warn the follower-locomotive operator of the necessity of a sudden stop because of numerous obstructions that may lie ahead of the preceding locomotive. Conversely, the follower-locomotive can be controlled to allow for emergencies requiring sudden stops without colliding with the preceding locomotive.

**Std. 55.* Cars should not be coupled or uncoupled by hand while they are in motion, provided, however, that this does not apply to the top or bottom men at slopes, planes, or shafts.

Coupling and uncoupling moving cars has resulted in the loss of many fingers and hands as well as more serious and fatal injuries. The risk taken is certainly not justified. Automatic and semi-automatic couplings on mine cars would tend to eliminate this hazard since the operating levers can usually be actuated without reaching between the cars *(41, p. 13)*.

**Std. 56.* Cars in motion should not be coupled or uncoupled by hand from the inside of curves.

The design of many mine cars has virtually eliminated the space between corners of adjacent cars on the inner side of curves. When uncoupling is attempted from the inside of

curves, the coupler or brakeman risks being squeezed as the cars approach one another *(41, p. 13)*.

Here again automatic couplings would tend to eliminate the hazard.

**Std. 57.* Locomotives approaching and passing through doors should be operated at reduced speed for at least 100 feet on each side of the door.

This requirement is made to insure control of the trip so that a stop can be made at the door. Damaging a door may interrupt the ventilating current. Reduced speed through a door decreases the possibility of derailment of any part of the train and subsequent damage to the door or injury to a person approaching the door.

**Std. 58.* Cars and trips should not be left standing in places where they will endanger other trips or persons or where they materially obstruct the ventilating current.

Self-explanatory.

**Std. 59.* Motormen, brakemen, drivers, and others should not leave ventilation doors or curtains open.

Short-circuiting of air, accumulations of gas, and ignitions of gas have frequently resulted from these practices.

**Std. 60.* An official or other authorized person should be in charge of and accompany each locomotive-hauled man-trip.

Discipline is necessary for safe transportation of men in man-trips. Getting on and off moving trips, horseplay, pushing, and crowding are some of the dangerous practices indulged in by men in unsupervised man-trips.

Std. 61. Man-trips should be operated at a safe speed but at no time in excess of 6 miles an hour.

The safe operating speed of a man-trip depends on the condition of the track and roadbed, rolling stock, and grades. The control of movement, such as signal systems or dispatchers, should be considered. Speeds exceeding 6 miles an hour are considered hazardous for man-trips *(41, p. 11)*.

**Std. 62.* Man-trips should not be operated immediately behind loaded trips on ascending grades or immediately in front of loaded trips on descending grades.

A safety measure to prevent accidents if loaded trips get out of control or cars become detached from the train.

Std. 63. Enough cars should be provided on man-trips to permit all men to ride inside and prevent crowding.

Self-explanatory (crowding causes discomfort and induces horseplay and risk).

Std. 64. Men on man-trips should not ride in the car next to the trolley locomotive unless such car is specially designed to afford front-end and overhead protection.

This is a requirement in the safety rules of many companies. If a trolley pole jumps from the wire and strikes loose roof, a

fall may injure the men in the first car. Dirt on the trolley wire is often dislodged and may fall into the eyes of men in the first car. It is possible for the trolley pole to touch the trolley wire and car at the same time, with possible electrocution of persons in the first car.

Std. 65. When riding in a car on a trolley haulage road, men should ride on the side of the car opposite the trolley wire unless suitably covered man cars are used.

This is to prevent men from coming in contact with the trolley wire while riding in the man-trip and to reduce the contact hazard when men are boarding or leaving the trip. Many mining companies enforce this rule.

**Std. 66.* Persons other than the brakeman should not be permitted to ride on the rear bumper of a man-trip, and no person should be allowed to ride between cars.

The danger of crushing men riding between cars or on the rear bumper because of derailments is obvious. Adequate space is seldom afforded between cars to permit comfort and when shifting position or the train lurches suddenly men may fall between the cars.

Std. 67. The man-trip should come to a full stop before men load or unload.

If men are permitted to board or leave a man-trip before it comes to a full stop they may stumble and be run over by the trip. The practice also results in general confusion during which injuries may occur.

Std. 68. Suitable places with seats should be provided at junction points where men may congregate while waiting for man-trips; they should be where the lives of persons waiting would not be jeopardized by run-away cars or trips or the wrecking of cars or trips.

Self-explanatory.

**Std. 69.* Only tools and supplies that can be carried entirely inside a separate car should be hauled on man-trips.

This standard is made to avoid injury to men because of stepping on, or stumbling and falling over or on, tools and supplies.

Std. 70. If there is any hazard of men touching the trolley wire at man-trip loading and unloading stations, the power should be cut off while men are loading or unloading; also, the wire should be adequately guarded at these stations.

Self-explanatory.

Std. 71. Barrier gates that close automatically or overpasses or underpasses should be provided at places where traveling ways cross haulageways.

To prevent men from being injured when entering haulageways from manways or while crossing haulageways.

SECTION 18. ELECTRICITY

Std. 01. Overhead high-potential power lines should be placed at least 15 feet above the ground and 20 feet above driveways and should be supported and guarded adequately to prevent contact with other circuits.

These recommendations are similar to those in the National Electric Code *(65, art. 730, sec. 7334, p. 263)*, quoted herewith:

"Overhead Conductors on Private Premises.

"7334. Clearance from Ground. Conductors shall be mounted with a clearance from ground as follows:

"*a.* Over Driveways. Conductors above alleys and driveways on other than residence property shall have a clearance above ground of not less than 18 feet, and if more than 600 volts, 20 feet.

"*c.* Over Footwalks, Etc. On residential properties, and elsewhere across spaces accessible to pedestrians only, conductors between buildings shall have a clearance above ground of not less than 10 feet for wires not more than 150 volts to ground, and 12 feet for higher voltages to ground. Greater clearances shall be provided if, in the judgment of the authority enforcing this code, it is necessary to prevent disturbance of the conductors."

Std. 02. High-potential power lines should be protected adequately by circuit breakers.

Circuit breakers are current-interrupting devices that can be adjusted to open electric circuits at predetermined current excesses. When properly installed and adjusted, they prevent overloading, damage to equipment from excessive current through short circuits, and the hazards resulting from overloading and short-circuiting.

"High potential" in this and the previous standard refers to alternating-current systems with voltages of over 600.

"Circuit breakers" should be interpreted to include proper types of fuses or other suitable automatic-current interrupters.

Std. 03. The wires of all circuits should be of ample capacity for the current carried.

The size of all conductor wires should be based upon the expected load and may be checked against the rated current-carrying capacity of the wire to determine if the wire is large enough. If the wires of all circuits are of adequate size, the dangers and difficulties common with overloading of circuits will be minimized.

Std. 04. DANGER—HIGH VOLTAGE signs should be placed on all transformer enclosures, high-potential switchboards, and other high-potential installations.

Self-explanatory.

Std. 05. Guy wires from poles supporting high-potential transmission lines should be grounded. If insulators are used, they should be installed near the poles.

This recommendation is designed to prevent poles or guy wires from becoming charged and thus presenting a hazard.

The National Electrical Safety Code *(67)* of the United States Department of Commerce, National Bureau of Standards, states:

"*B.* Use of guy insulators.

"1. One insulator—An insulator shall be located in each guy which is attached to a pole or structure carrying any supply conductors of more than 300 volts to ground and not more than 15,000 volts between conductors, or in any guy which is exposed to such voltages. This guy insulator shall be located from 8 to 10 feet above the ground.

"2. Two insulators—Where a guy attached to any pole carrying communication or supply conductors, or both, is carried over or under overhead supply conductors of more than 300 volts to ground and where hazard would otherwise exist, two or more guy insulators shall be placed so as to include the exposed section of the guy between them so far as possible. Neither insulator shall be within 8 feet of the ground.

"Exception—

"4. Conditions not requiring guy insulators—Insulators are not required in guys under the following conditions:

"*a.* Where the guy is electrically connected to grounded steel structures or to a ground connection on wood poles.

"*b.* Where the guys are uniformly permanently grounded throughout any system of overhead lines."

Std. 06. Surface transformers within 15 feet of the ground should be enclosed in a transformer house or by a substantial fence suitably located and at least 6 feet high.

Std. 07. The gate or door to the transformer enclosure should be kept locked at all times unless authorized persons are present.

These are safety precautions designed to prevent unauthorized and curious persons, children, or animals from contacting the transformers and sustaining fatal electric shock.

Std. 08. Casings of all transformers should be grounded unless protected by isolation (freedom from contact hazard by position or fencing).

Necessary to prevent charging of the transformer casings with consequent shock hazard to attendants.

Std. 09. Switchboards should:

**a.* Have ample working space around and back of them, free of rubbish and stored material.

b. Have entrances at each end to permit authorized persons to inspect, adjust, or repair apparatus back of switchboards.

c. Be adequately lighted.

d. Have controls readily accessible for emergency shut-down.

e. Have cut-out switches on incoming circuits.

f. Have entrances to rear guarded.

Explanation:

a. This is a contact and fire-prevention precaution.

b. Where there is only one switchboard panel and it is accessible only from one end, do not recommend that its position be changed to provide two entrances. The Pennsylvania Bituminous Mining Laws provide *(77, art. XI, sec. 3, par. 18,*

p. 82), with reference to underground stations and transformer rooms: "The space at the back of the switchboards shall be properly floored, accessible from each end, and in the case of high-voltage switchboards, shall be kept locked up, but the lock shall allow of the door being opened from the inside without the use of a key. The floor at the back of high-voltage boards shall be incombustible." The same Pennsylvania law defines *(77, art. XI, p. 76)* high-voltage supply thus: "Where the conditions of the supply of electricity are such that the difference of potential between any two points in the circuit may at any time exceed six hundred and fifty volts, the supply shall be deemed a high-voltage supply."

The standard concerning switchboards applies to both surface and underground installations.

c. Adequate fixed lighting is desirable so that the switchboard may be operated quickly and properly, repairs made more readily, and contact hazards lessened.

d. Self-explanatory.

e. This recommendation requires a cut-out switch in the incoming circuit at or near a rear entrance to the switchboard so that all current may be readily cut off the board to permit repairs and alterations to the board.

f. This recommendation is to keep unauthorized persons from behind the board. The guarding should preferably be a gate locked in such a manner that it can be opened from the inside without a key.

**Std. 10.* Rheostats and electric heaters should be placed safe distances from combustible material and effectively protected against contact and fire hazards.

Rheostats and electric heaters are resistors and can be treated as such insofar as installation is concerned.

"Resistors and reactors shall not be placed where exposed to mechanical injury. If in the immediate vicinity of easily ignitible material, they shall be of the oil-immersed type or shall be enclosed in metal boxes or cabinets" *(65, art. 470, sec. 4701, p. 184).*

Std. 11. Switches and circuit breakers controlling the operation of stationary motors and electric lighting should be so placed that they are readily accessible and can be reached without danger of contact with moving or charged parts.

Self-explanatory.

**Std. 12.* Electric wiring in all surface buildings should be so installed as to present minimum fire or contact hazards.

All electric wiring should be well-installed, properly insulated if not enclosed in conduit, provided with proper fuses or other suitable protective devices, and of proper size to carry the required load.

The National Electrical Code (1940) is the Standard of the National Board of Fire Underwriters, is recommended by the National Fire Protection Association, and is approved by the

American Standards Association. If its provisions concerning surface wiring are followed, buildings and persons should be amply guarded from electrical hazards arising from the use of electricity.

Std. 13. All electrical appliances, machines, and conductors should be sufficient in size for the required work.

Technical Paper 402 *(13, p. 5)* gives the current-carrying capacity of bare copper conductors. The capacity of insulated conductors is given in the 1940 National Electrical Code *(1, chap. 10, tables 1 and 2, pp. 301-302).*

The importance of using proper-size wires for conducting current deserves emphasis. If too small wires are used, the conductors are likely to heat excessively, or the voltage loss may be such as not to permit proper or efficient operation of motors and cause damage to them. The overheating of circuits can obviously cause fire and gas-ignition hazards.

Std. 14. All metallic coverings and armor of cables and all conduit should be grounded and should be electrically continuous to afford a conductor path for the ground current.

By grounding is meant making a permanent connection to the general mass of earth in such manner as will insure at all times an immediate discharge of electrical energy to the earth without danger. The grounding medium should be in contact with permanently moist earth.

Ground wires should be straight and as short as possible.

"3. Ground-wire connections to the apparatus shall be made by means of terminals soldered to the ground wire and securely bolted to the apparatus where its removal will be unnecessary for inspection and repair.

"4. All ground connections shall be made to pipe lines, track, or to buried ground plates or pipes which shall be in contact with permanently moist earth, these connections to be mechanically secured and soldered or welded" *(84).*

"Electric cables often carry high voltages, and if a fault occurs in the cable, the sheath becomes charged with a high potential. A continuous grounding of the sheath or armor throughout the length of the cable reduces the shock hazard that would otherwise exist" *(45, p. 2).*

"Where the cables are provided with a metallic covering constructed and installed in accordance with Regulation (*c*), such metallic covering may be used as a means of connection to the earthing system. All the conductors of an earthing system shall have a conductivity at all parts and at all joints at least equal to 50 percent of that of the largest conductor used solely to supply the apparatus a part of which it is desired to earth. Provided that no conductor of an earthing system shall have a cross-sectional area of less than 0.022 of a square inch *(47, p. 2).*

"All joints in earth conductors and all joints to the metallic covering of the cables shall be properly soldered into a lug for each of its terminal connections. No switch, fuse, or circuit breaker shall be placed in any earth conductor" *(47, p. 3).*

Std. 15. All metallic frames, casings, and coverings of motors, generators, switchboards, and other electrical equipment that can become "alive" through failure of insulation or by contact with energized parts should be grounded.

Note to inspector: All electrical equipment having a rated capacity of 15 horsepower or 10 kilowatts or more should be provided with a frame ground equivalent to No. 0 copper wire. Electrical equipment having a rated capacity less than 15 horsepower or 10 kilowatts should be provided with a frame ground equivalent to No. 6 copper wire.

The sizes of ground wire given in the note under this standard apply to stationary electrical equipment of comparatively large horsepower. For portable equipment such as cutting machines and drills, the ground conductor should be equal to the size of the power conductor.

The general subject of grounding is covered in a Bureau of Standards paper *(78)*. A Bureau of Mines report *(37)* discusses grounding tests made with shortwall direct-current mining machines, pumps, and conveyors. This report brings out the unreliability of "peg" grounds and of grounds based on metal parts of equipment resting on mine floors. Fish-plated, unbonded track usually was found to be a satisfactory electrode. The only dependable method of determining the effectiveness of a protective ground is to measure the resistance of the grounding connection, and the maximum resistance desirable is 3 ohms. Various direct-reading instruments are on the market; these testers include the Megger and the Vibroground.

A well-bonded track or a water line to the surface is a satisfactory medium for protective grounding of direct-current or alternating-current machines or both. However, if there is a break in the track, there may conceivably be a hazard of the return circuit taking a path through the cable armor, which might be grounded to the track, resulting in damage to the cable. Possible electrolysis when pipe is used as an emergency grounding connection is not thought to be important by the Electrical-Mechanical Section of the Bureau of Mines, but further studies will be made. With alternating-current installations, a fourth wire as a grounding conductor extending to the surface constitutes complete grounding protection.

The following information was furnished by Bureau of Mines electrical engineers:

The term "grounded" means connected to "earth" or to some extended conductor which is at "earth potential," such as the negative side of a direct-current generator or the neutral of a Y-connected alternating-current system. "Grounded" and "live" are not synonymous. Should an uninsulated current-carrying conductor come in contact with a mining machine, the frame of the mining machine is said to be "alive" but not "grounded." A person in contact with both the machine and the earth causes a current to flow through his body as a result of the potential difference between the frame of the machine and the earth. However, if the machine is effectively grounded, the voltage would be instantaneously reduced to "neutral" or "earth poten-

tial" through the grounding conductor, and the shock hazard would be eliminated.

The grounding wire does not necessarily need to be connected to the earth itself but may be attached to some conductor having the same potential as earth.

Briefly, to eliminate shock hazards through contact with a "live" machine, it is necessary to provide some means of keeping the frames of machines at "earth" or "neutral potential."

The grounding of an ungrounded rotary converter need not be recommended. This subject is discussed by the supervising engineer of the Electrical-Mechanical Section of the Bureau of Mines as follows:

"If the frame of a rotary converter is solidly grounded and there is an arc-over in the machine it will probably cause a dead short to ground. Considerable damage to the machine itself might follow. Consequently, for the protection of the machine, one electrical manufacturer recommends a resistance or relay in the grounding circuit to limit the flow of current that otherwise would be destructive to the machine. This would not protect men against shock.

"For the protection of men, the Bureau of Mines should recommend that all machines be completely surrounded with an insulating mat or floor so that the men would have to stand on this floor before touching the machines. If the characteristics of a machine are such that grounding of the frame would make the machine more liable to damage than without, it might not be advisable to recommend grounding."

Objection has been raised to grounding the frames of electrical equipment because, in at least one mine, the drill motors burned out. In such instances, the maintenance of the electrical equipment is at fault, and men's lives obviously were imperiled by such poor maintenance. The maintenance, rather than the grounding, was subject to criticism and recommendation.

Std. 16. Where a grounded return system is used, all underground metallic pipe lines 1,000 feet or more in length and all metallic pipe lines leading outside the mine should be bonded to the return at the ends and also at intervals not exceeding 500 feet.

Observance of this precaution serves to reduce the amount of stray electric current and prevent metallic pipe lines from becoming charged.

Std. 17. The frames of drills and other electric tools intended to be held in the hands while being operated should be grounded.

"The necessary intimate contact of the user with these drills increases the shock hazard. Also, the light weight and small size required to permit hand operation make adequate insulation for high voltages more difficult. The potential for permissible drills of this class has, therefore, been limited to 250 volts for direct current. In addition, the frames of these drills must be grounded by a separate conductor" *(52)*.

Std. 18. Dry wood platforms, rubber mats, or other electrically nonconducting material should be kept in place in front of and around all switchboards, starting switches, and stationary electrical installations underground.

This is a shock-prevention measure.

"Noncombustible flooring only shall be used at the front and back of high-voltage boards, and insulating mats or their equivalent shall be provided on the floor in front and back of all boards whatever the voltage" *(85, sec. 81(d), p. 43).*

Std. 19. Wires or other substitutes that do not provide adequate protection should not be used in place of proper fuses.

"Fuses and circuit-breakers are the safety valves of an electrical circuit. They blow or open when the current in the circuit reaches the predetermined safe load. If this warning is not heeded then the wiring of the apparatus itself is likely to be damaged as a consequence. Anyone using oversize fuses or solid wire instead of fuse or any other means of defeating the fuse (circuit breaker) deserves to be disciplined" *(45, p. 5).*

Std. 20. Electrical equipment should be protected against excessive overload by fuses or equivalent protective devices of the correct type and capacity.

See explanation of standard 18–19. Oversize fuses or incorrectly designed fuses are worthless, and only a false sense of security is provided.

Std. 21. Clean, dry sand or rock dust and, if available, fire extinguishers, suitable from both a toxic and shock standpoint, should be provided and placed outside underground electrical stations so as to be out of the smoke in case of fire in the station.

"Several important factors must be considered in the application of portable extinguishers to fighting fires in electrical equipment in mines: (1) Some extinguishers are filled with liquids which, when decomposed by electric arcs or heated surfaces, give off poisonous gases; (2) the liquids or some extinguishers are conductors of electricity, therefore their use on electrical fires might result in shock to the fire fighter; and (3) the possible damage to electrical equipment resulting from the corrosive and solvent action of certain chemicals makes it inadvisable to use some extinguishers" *(29, p. 14).*

The National Fire Protection Association: Crosby-Fiske-Forster Handbook of Fire Protection *(15)* states that, for electrical fires vaporizing liquid (or carbon tetrachloride), carbon dioxide, dry compound extinguishers, and sand are suitable for use in their extinction. However, there may be irritating or toxic fumes formed when carbon tetrachloride is sprayed on a fire and, therefore, the following recommendation is quoted: "It is recommended that carbon tetrachloride fire extinguishers be not used on fires in closely confined spaces when conditions are such that the user cannot escape without breathing the fumes *(21).*

Owing to the limited supply of available fire extinguishers during the war, it may be advisable not to recommend these

unless definite knowledge is gained concerning the supply. Rock dust and sand can be obtained, however.

Std. 22. If track is used for the return circuit, both rails should be well-bonded at every joint and cross-bonded at least every 200 feet or at intervals that will assure an efficient return circuit; rail-joint bonds and cross-bonds should be properly installed and maintained in good repair.

"The tracks of all main haulage systems that use a rail return shall be bonded at every rail joint, and cross-bonding shall be placed at intervals not exceeding 200 feet. Special provision shall be made for bonding around all switches, frogs, or openings in the track so as to insure a continuous return" *(13, p. 19)*. Obviously, welded rail joints need not be bonded, but track so laid should be cross-bonded at least every 200 feet.

Std. 23. Instructions on artificial respiration should be posted at every electric station and at or near the entrance to the mine.

Std. 24. All employees working with or around electrical equipment should know how to give artificial respiration.

"There should be posted prominently in every surface and underground station and at the entrance to the mine instructions for the restoration of persons suffering from electric shock. All employees who work with or on electrical apparatus should know how to carry out these instructions without delay" *(50, p. 7)*.

**Std. 25.* Wiring in underground structures should be insulated and installed properly.

"All underground circuits should be properly installed in a permanent manner. Proper installation should mean support on insulation adequate both mechanically and electrically, taking into consideration weights to be supported, the voltage to the circuit, clearance from ground interference with other circuits, and liability to damage from the usual mining hazards. Lighting circuits and branch power circuits should be given the same degree of care in installation as power circuits of the same nominal voltage. All wiring between motors and their controlling appliances should be insulated or guarded" *(50, p. 17)*.

Although the above quotation applies to all underground wiring, good wiring in underground structures or stations is of particular importance because of the possibility of an electrical fire in such a station spreading to considerable proportions before its discovery.

Std. 26. Telephone circuits should be protected on the surface by lightning arresters (protector blocks).

This standard deals with circuits originating on the surface and extending underground.

Telephones and the telephone electric systems should be protected from high voltage and lightning. High-voltage "protectors" are available commercially and usually consist of two 7-ampere fuses and a ground-connection terminal; installed, one

at each telephone, these assemblies guard the user of the telephone only from voltage in excess of 350 volts.

"Where the distribution system consists of aerial wires, an approved protector shall be placed as near as practicable to the point of entrance to the building. The protector shall be mounted on a noncombustible, nonabsorptive insulating base and shall consist of an arrester between each line wire and ground and a fuse in each line wire, the fuses protecting the arrester. The protector terminals shall be plainly marked to indicate 'line,' 'instrument,' and 'ground.'

"The protector shall not be placed in the immediate vicinity of easily ignitible material or inflammable gases, or dust or flyings of combustible material.

"Where the entire street circuit is run underground, a protector shall not be required unless the circuit within the block is so placed as to be liable to accidental contact with electric light or power wires operating at a potential exceeding 250 volts" *(1, sec. 3316, p. 480).*

Std. 27. Trolley and bare power wires should be:

a. Securely supported on insulated hangers not more than 30 feet apart.

b. Kept taut and not permitted to touch the roof, rib, collars, or doorframes.

c. Properly alined.

d. Installed on the opposite side from the clearance side and shelter holes, where feasible.

**e.* Sectionalized by proper electric switches at suitable intervals; electric switches should also be installed in all branch lines near their beginning.

f. Provided with cut-out switches where mine cars are stored on idle days.

**g.* Adequately guarded where men are required to pass under the wire, unless the wire is 6½ feet or more above the top of the rail.

h. Cut off and anchored with an insulated turnbuckle or a strain insulator at the inby end.

The Safety Rules for Installing and Using Electrical Equipment in Coal Mines, sponsored by the Bureau of Mines and the American Mining Congress, provide *(13, pp. 18-19):*

"93. Trolley wires.—*(a)* Trolley wires shall be of hard-drawn copper not smaller in size than No. 00 A. W. G. and shall be securely supported on approval hangers.

"*(b)* Trolley wires shall be placed 6 inches outside of the rails, kept in as straight a line as practicable, and installed on the side of the entry opposite from shelter holes or traveling way or space. The height of trolley wires above the top of the rails shall be made as uniform as possible.

"*(c)* On straight runs, the hangers shall be placed not more than 20 feet apart where the height of the roof above the rail is 5 feet or less, and not more than 30 feet when the height above the rail is more than 5 feet. In any event, the sag of wire between any two adjacent hangers shall not exceed 3 inches. On curves the hangers shall be placed so close together that the

trolley wire at any one hanger may be entirely disconnected without exposing the locomotive runner to danger of contact.

"(d) Sectionalizing switches shall be placed in the underground trolley wires and their feeders at intervals not exceeding 2,500 feet. These switches shall be arranged so they can be locked in the open position.

"(e) All branch trolley circuits shall be provided with a frog at the point where they leave the main, and also with a switch installed at or near the frog, by which the branch can be disconnected from the main.

"(f) Trolley wires that are less than 6½ feet above the top of the rail shall be guarded at the points where men are daily required to work or pass under them."

Recommendation 27*e*—Sectionalizing trolley wires—An interval less than 2,500 feet is preferable when new installations are made because the more convenient the switches the sooner the wires can be deenergized if an emergency arises. The Bituminous Standards recommend 1,500-foot intervals for new installations *(84, p. 35)*.

Sectionalizing or cut-out switches should be placed in branch circuits where cars are stored on idle days. Several mine fires have been started when trolley wires were detached from the hangers and contacted steel cars filled with coal.

(g) Trolley-wire guarding is covered in Mine Safety Board Decision 24 *(63, pp. 33-34)*.

Many mines have installed continuous guards along trolley lines. A thorough guarding program could be started and carried to completion as materials and labor are available.

(h) "All trolley lines shall be dead-ended by an insulated turnbuckle and dead-end cam grip * * * same to be suspended from hook or eyebolt of appropriate design" *(84, p. 36)*.

**Std. 28.* Power wires, whether bare or insulated, should be supported on or by well designed and installed insulators. (This does not apply to armored cable carried on metal supports.)

Std. 29. Power and trolley wires should be properly guarded on both sides of all doors.

These recommendations are to prevent fires by keeping power wires insulated from all combustible matter.

"Other power cables should be supported on insulators, preferably of porcelain, placed not more than 30 feet apart and closer together where the cable is run around curves. The cable should be so installed that it does not rest against rock, coal, timber, or other conducting material. Hanging of insulated cables on spikes or allowing them to lie on mine timber is dangerous practice.

"A trolley circuit to give good service should, as far as feasible, be strung at a uniform height and have enough insulators to give the line the same contour as the track. Insulator supports should be such as to keep the circuit from touching the roof or sides of the rock, coal, or timbers" *(45, p. 3)*.

Trolley wires should be guarded on both sides of doors because men must approach the wire to manipulate the door.

Std. 30. Power wires, other than trolley wires, should be properly insulated when passing through doors or stoppings.

Insulation is necessary to prevent contact with combustible materials; a fire-prevention measure. See also explanation of standard 18–29.

Std. 31. Power should be disconnected when repair work is being done on electrical equipment and accessories, such as trailing cable, feed wire, trolley wire, switches, junction boxes, and the like.

"Repairs, renewals, or extensions of electrical apparatus and circuits should be made while such apparatus are not alive. If conditions are such that repairs need be made on live apparatus or circuits, the utmost precaution should be taken when working on them. Gloves or mats of rubber or other suitable insulating material should be provided and be used by persons making repairs to live apparatus or circuits, or when live parts of electrical apparatus need be handled for the purpose of adjustment. When working on apparatus or circuits that have been disconnected from the power supply, precautions should be taken to prevent unauthorized persons from closing switches that will cause such apparatus or circuits to become alive" *(50, p. 7).*

**Std. 32.* The ends of trolley or feed wires should not extend beyond the last open crosscut, chute, or heading, and should be kept at least 150 feet from the end of pillars, workings, or any open, partly caved, poorly ventilated places.

Several mine disasters have been attributed to the practice of operating electrical equipment in advance of fresh air, near pillar workings, and partly caved places where there is a likelihood that methane gas may be liberated in dangerous quantities.

The Pennsylvania Bituminous Mining Laws *(77, art. XI, sec. 6, par. 77, p. 102)* require that "It shall be unlawful in any gaseous portion of a mine, as defined in this rule, to run or operate a locomotive fed directly or indirectly from a trolley wire by the open entrances to worked-out places wherein the pillars have been drawn, or places in which the pillars have not been drawn, but in places where the roof has collapsed, unless such places are constantly and thoroughly ventilated and examined as frequently for explosive gas as active working places are examined."

Std. 33. If feasible, power should be cut off from idle sections of a mine and cut off from the entire mine on idle days. This statement is not, however, intended to bar the use of lines properly protected by fuses or circuit breakers for the operation of units such as pumps, if all passageways and adjoining areas through which live circuits pass, including surroundings of units, are examined with a flame safety lamp and found free of gas.

Numerous mine fires have been caused by falls of roof on live trolley and other power wires. Many of these have occurred on idle days. Methane has been ignited by electric arcs from motors, when control switches were closed following a lapse of operation.

Std. 34. Underground electrical equipment should be provided with switches of safe design, construction, and installation.

"All switches intended for underground use should be rugged in construction and adequately proportioned and where practicable of the safety enclosed type. Knife switches operating on circuits having potentials exceeding 125 volts should be designed so as to prevent excessive arcings. Insofar as possible, switches should be located in a relatively dry place. If switches cannot be so located an insulating platform should be provided for the man to stand on when operating the switch. Where practicable, switches should be so designed or wired that they will not close by gravity. Switches should be conveniently located and accessible, yet so safeguarded that the liability of accidental contact with the live parts will be reduced to a minimum. Air-break switches used as disconnecting switches should not under any circumstances be used to open circuits under load. Where there is danger of accident due to the inadvertent closing of an open switch means should be provided for locking the switch in the open position" *(50, p. 16).*

If the platform recommended is a stumbling hazard, an insulating mat may be substituted.

See also standard 18–18 and explanation thereof.

Std. 35. Officials, haulage crews, electricians, and others connected with electrical maintenance should be familiar with the locations of cut-out switches.

Avoids confusion and delay when an emergency arises.

Std. 36. Cut-out switches should be marked so that they may be found readily in case of emergency.

"Appropriate signs designating the locations of disconnecting switches shall be placed along the line" *(84, p. 35).*

Std. 37. Circuit breakers should be provided to protect all power circuits. If they are automatic, they should be set so that the circuits cannot be overloaded; if they are hand-set, the handles should not be tied in place.

Information Circular 6100 states *(44, p. 7):* "All circuits and apparatus should be of sufficient size to perform their work without overheating and should be protected by circuit-interrupting devices against sustained overloads. Automatic reclosing circuit breakers are proving successful on the main-line circuit, but would probably add to the fire hazard if used on branch circuits."

In view of the above, automatic reclosing circuit breakers should not be recommended for branch circuits; on the other hand, their removal from branch circuits should not be recommended.

The main purpose of a circuit breaker is to prevent damage to electrical equipment from sustained overloads. The protection they afford against fire is likely to be partial and very incomplete, in that a short circuit sufficient to start a fire can conceivably occur without opening a circuit breaker.

*Std. 38. Underground electric stations for permanent installations of pumps, hoists, compressors, motor-generator and other conversion equipment, battery-charging stations, and transformers should be located in well-ventilated fireproof rooms.

The Pennsylvania Anthracite Mining Law states *(76, sec. 1)*: "* * * All buildings inside of any coal mine in Pennsylvania, including engine-houses, pump-houses, stables, etc., shall be constructed of incombustible material * * *."

Information Circular 6981 *(29, p. 12)* recommends that electric stations be fireproofed by the use of gunite, concrete, or concrete slabs. It further states, "Because of the heat generated in the operation of electrical equipment it is necessary to provide ventilation for substation and transformer rooms to prevent damage to equipment from overheating." Preferably the return air from electric stations should be conducted to a main return airway and not coursed through working places or haulageways.

*Std. 39. Permanent battery-charging stations should be located on separate air splits, the return from which does not pass through any active workings. Such stations should be installed in fireproof rooms.

With battery-charging stations there is a potential fire hazard because of the power cables and also because of the hydrogen gas generated during battery charging.

"More underground battery-charging stations used for charging storage-battery locomotives (and shuttle cars) are found in mines as the use of these machines is extended. Such stations should be fireproof and installed where a supply of fresh air ample for ventilation can be obtained" *(45, p. 9)*.

The return air from battery-charging stations should not be coursed through active working places or haulageways owing to the explosibility of the hydrogen liberated and the possibility of fumes from a fire within the station being carried to employees in other parts of the mine.

*Std. 40. The surroundings of temporary battery-charging stations should be of incombustible material or should be made fire-resistant.

See explanation of first part of standard 18–39. Fireproofing can be attained by guniting combustible surfaces. Numerous inexpensive fireproof materials are available for constructing temporary stations, and these materials may be reclaimed when the station is moved or discontinued.

*Std. 41. Telephone service should be provided from the surface to the working sections of a mine 2,500 feet or more distant from the surface.

"Telephones should be designed for underground service and constructed so as to guard the essential parts of the telephone from dust and moisture. Every mine employing more than 10 men underground should be equipped with a telephone system that should afford communication from the surface to the bottom of each of the underground levels or landings, and from the surface to each *parting* or siding in the working sections of

the mine. In complying with this rule, the telephones may be located at the most advantageous points underground, but in no case should any part of the working section be more than 1,500 feet from the nearest telephone" *(50, p. 16)*.

Communication is absolutely essential to safe, efficient operation. Unnecessary delay in obtaining assistance if serious accident occurs or other emergency arises may mean loss of life or costly interruption of operations.

Std. 42. Telephone wires should be installed on the opposite side from power or trolley wires where at all practicable. If telephone lines are installed on the same side as power or trolley wires, they should be protected by insulating transformers.

Std. 43. Telephone wires crossing power or trolley wires should be adequately insulated.

Std. 44. Telephones should be grounded or protected by insulating transformers (repeating coils).

"*(a)* Underground battery-signal circuits and telephone wires shall not be installed on the same side of an entry as trolley wires or other power conductors. Where signal or telephone wires cross trolley or power wires, they shall be insulated and boxed in or encased in conduit.

"*(b)* Suitable precautions shall be taken to prevent electric signal or telephone wires from becoming grounded or from coming in contact with other underground electric conductors" *(13, p. 20)*.

To protect against possibly fatal voltage from mine circuits, the metal cases of iron-clad or metal-enclosed telephones should be effectively grounded with the equivalent of No. 1/0 single-strand copper wire or protected by insulating transformers. Obviously, this standard does not apply to old-type wood telephone cases.

Frequently, in the coal-mine inspector's experience, mine electricians and operators object to, or have tried and rejected, the grounding of telephone cases, because the result of incipient failure of insulating materials within the telephones is aggravated by the grounding and the grounded telephones cannot be used. Devices known as repeating coils or insulating transformers are available for protecting such telephones. (Western Electric No. 67–c costs about $10.30.) The repeating coils must be installed at, and close to, each telephone between the high-voltage protector and the telephone. Repeating coils, used alone, afford no protection from lightning or high-voltage alternating current. Well-installed combinations of high-voltage protectors and repeating coils obviate the need for grounding the telephone cases. Where a central ringing system is in effect, it is necessary, when insulating transformers are used in the telephone circuits, to use a magneto in order that the telephone bells may be rung from a central point.

Std. 45. Signal wires should not carry more than 24 volts. (This does not apply to block-signal systems.)

The Pennsylvania Bituminous Mining Laws state *(77, art. XI, sec. 9, par. 100, p. 108):* "In any gaseous portion of mine, the potential used for signal purposes shall not exceed twenty-four volts, and bare wires shall not be used for signal circuits, except in haulage roads."

The standard, "Signal wires should not carry more than 24 volts," applies only to bare-wire electrical signal systems in which hand-operated means are used to close the circuits and operate the signal devices, as on slope haulage. Block-signal systems, with signal lights and electric switches operated from the regular mine-power source, or magnetos, should not be considered to fall within the limits of this recommendation.

The 24-volt limitation is made because of the shock hazard involved with higher voltages, particularly with alternating current. Considerably less than 24 volts can ignite gas.

Std. 46. Signal wires should be supported on insulators.

This recommendation is to prevent short-circuiting of signal wires where bare conductors are used. Such short-circuiting may result in ineffective or false signaling.

"Supports for slope signal wires should not be more than 20 feet apart, and the distance between wires shall be 6 inches. All wires shall be drawn taut and extend the full length of the slope" *(84, p. 2).*

"* * * Suitable precautions should be taken to prevent electrical signal or telephone wires from becoming grounded or from coming in contact with other underground electric conductors *(50, p. 22).*

Std. 47. Permanent underground stations having transformers filled with inflammable oil should be provided with doors which close automatically in case of fire. When practicable, these stations should be on separate air splits leading to the return; such stations should be provided with door sills, or their equivalent, that will confine the oil in the event of leakage or explosion.

Statements are made in Information Circular 6981 *(29, pp. 12-13):* "Fire doors are necessary to close off ventilating openings if the rooms are to be isolated when fire starts in them. In some transformer vaults steel doors are hung by horizontal hinges over the ventilating openings. The doors are held open by cords run through pulleys in the roof and then passed over the transformers so that flames from the transformers will burn the cord and allow the doors to drop. Sometimes fusible links are tied in the cord to insure release of the doors. If the door-frame is inclined at a slight angle rather than vertically the door is more certain to seat tightly after it has been released. * * * Counterweights can be arranged so that the doors will close when they are released by the burning of the cord or the melting of fusible links. Counterweights should be suspended by incombustible rope or chain and should be guarded so that they will be always free to travel the full distance required in closing the doors.

"When the equipment contains large quantities of oil, as do transformers, the fireproof room should be made with doorsills high enough to prevent the escape of oil should the containers burst or spring a leak. A layer of sand and gravel several inches deep on the floor of transformer rooms should be used to soak up leaking oil."

If practicable, such transformer stations should be in separate air splits so that, if fire occurs, all smoke and noxious gases formed would be carried directly into the returns instead of the active working sections.

**Std. 48.* Portable transformer stations should be in fireproof housings either fully enclosed or fitted with doors which close automatically in the event of fire. They should be located only in well-ventilated places.

"Self-contained portable transformer boxes have been used to some extent instead of fireproof rooms of brick, tile or concrete. For this purpose boxes made of steel plate are mounted upon a mine-car truck to facilitate movement about the mine. The transformers are permanently fastened in place and connected up. The primary and secondary switches also are secured to the boxes. The arrangement permits the transformers and switches to be moved without disturbing the wiring between them, and as the box itself is the fireproof enclosure it is not necessary to tear down and build up fireproof walls each time the unit is moved" *(29, p. 13)*.

This recommendation is designed to assure protection against fire hazard. Ventilation is essential to dissipate heat and carry away any fumes liberated.

Std. 49. A potential higher than 250 volts should not be used for operating drills or other electric tools intended to be held in the hands. Electric drills or other electrically operated rotating tools intended to be held in the hands, and, where feasible, post drills should have the electric switch so constructed as to break the circuit when the hands release the switch.

"The necessary intimate contact of the user with these drills increases the shock hazard. Also, the light weight and small size required to permit hand operation make adequate insulation for high voltages more difficult. The potential for permissible drills of this class has, therefore, been limited to 250 volts for direct current and 220 volts for alternating current. In addition, the frames of these drills must be grounded by a separate conductor" *(52, p. 2)*.

"The first change in the 2–BF approved coal drill eliminated the snap switch, which was replaced by a spring-operated switch designed to open automatically unless held closed" *(52, p. 4)*.

Std. 50. Electrically driven equipment that is operated inby the first open heading or crosscut between chambers or breasts, between gangways and airways, or in air that has ventilated one or more working places in mines classed as gassy should be permissible. It is recognized that under war conditions it may be difficult, if not impossible, to obtain permissible equipment and that nonpermissible equipment is now and will continue to be used in gassy mines. Where such equipment is used, all possible precautions should be taken.

Nonpermissible equipment has been known to be the source of many explosions and fires.

"Permissible equipment" is defined as equipment that has been inspected and tested in accordance with Bureau of Mines procedure as outlined in Bureau schedules and that bears an approval plate.

Permissible equipment has special merit because it meets the following conditions:

1. The compartments have been inspected for design and construction.

2. The compartments have been tested by the Bureau to prove the safety of their construction.

3. The wiring of the machine as a whole has been considered by the Bureau from the safety standpoint.

4. The approval-plate wording has been prepared by the Bureau to call attention to ways and means of keeping the machine in a safe condition.

5. The Bureau maintains detailed records of the construction of the electrical parts and of any changes made from time to time.

6. The Bureau holds the manufacturer responsible for the continued construction of machines in accordance with Bureau records.

Nonpermissible machines found in coal mines range from machines with none of the above safety features to machines having a measure of safety in that they may meet the first two of the six conditions outlined for permissible equipment. The degree of safety of nonpermissible equipment is extremely difficult if not impossible to determine by a field inspection. Therefore, the continued use of these machines is a responsibility that should be assumed by those reponsible for their installation.

Std. 51. If nonpermissible electrical equipment is used in face regions (inby first open crosscut or air that has ventilated one or more working places) of gassy mines, it should be operated only under the following conditions:

**a.* Each working place should be carefully examined for methane by a certified official or other competent person immediately before the equipment is taken into or operated in a working place.

**b.* Electrical equipment should not be taken into or operated in any place if methane can be detected by a competent person in the general air of the place with a permissible flame safety lamp, or if methane can be detected in amount of more than one-half of 1 percent by an electric methane detector. By "air of the place" is meant air not nearer than 1 foot from the face.

**c.* If methane can be detected in holes in the roof with a permissible flame safety lamp or in amount of more than 1 percent by an electric methane detector, electrical equipment should not be taken into or operated in place until the pocket of gas has been removed by additional ventilation.

**d.* When electrical equipment is used in face regions, tests for methane should be made at least every 30 minutes by a certified official or other competent person.

e. Replaced equipment, so far as feasible, should be of permissible type.

a. Since nonpermissible electrical equipment is capable of igniting gas, this recommendation is designed to assure that no dangerous quantity of methane is present in the working place.

b and *c.* These recommendations are made to minimize any possibility of gas ignition.

Several methods of gas detection have been devised, such as electrically operated methane detectors, flame safety lamps, and chemical analyses. It must be remembered that electrically operated methane detectors are not infallible, and testing with a second detector is advisable to assure that the information is accurate. Two percent of methane is usually easy to detect with a flame safety lamp, using the testing flame (flame devoid of yellow color). Approximately a 0.45-inch cap will appear in the presence of 2 percent of gas.

"General air of the place" is defined as air not nearer than 1 foot from the face to (on the one hand) avoid classing air found in a high place at the face as representative of the general air, and to (on the other hand) assure that air in contact with drill cables is tested and found to contain no inflammable gas which could be ignited by a faulty cable.

d. The Bituminous Mining Laws of Pennsylvania provide *(77, art. XI, sec. 5, pars. 71-73, pp. 99-100):*

"71. No man shall be placed in charge of a coal-cutting machine in any gaseous portion of a mine who is not a competent person, capable of determining the safety of the roof and sides of the working place and detecting the presence of explosive gas.

"72. In any gaseous portion of a mine, a coal-cutting machine shall not be brought within the last break-through next to the working face, until the machine man shall have made an inspection for gas in the place where the machine is to work, unless such examination is then made by some other competent person authorized or appointed for that purpose by the mine foreman. If any explosive gas is found in the place, the machine shall not be taken in.

"73. No coal-cutting machine shall be continued in operation in a gaseous portion of a mine for a longer period than half an hour without an examination as above described being made for gas, and if gas is found the current shall at once be switched off the machine, and the trailing cable shall forthwith be disconnected from the power supply."

Obviously, in very gassy places or in places in disturbed strata (as found during a squeeze) extraordinary precautions should be taken and gas examination should be made every 15 minutes or oftener.

e. Each piece of nonpermissible electrical equipment in a gassy mine is likely to increase the gas-ignition hazard.

Cable-reel locomotives of the explosion-tested or explosion-proof type are used for gathering service in many mines. All the electrical enclosures have been tested by the Bureau of Mines for explosion-proof qualities. Where these and their trailing cables are found to be in proper condition by the same

methods of inspection as used by the inspector on permissible equipment, no recommendation should be made that they be supplanted by permissible storage-battery locomotives; if they are found in unsafe condition, immediate repairs should be recommended. However, the use of the trolley pole and trolley wire with this locomotive with respect to possible gas-ignition hazards should be scrutinized carefully and recommendation made, if needed, as to how far trolley wires should be kept from faces. See explanation of standard 18–32.

NOTE: Explosion-tested locomotives should be equipped with a two-conductor rather than a single-conductor trailing cable.

**Std. 52.* Electrically driven permissible equipment should not be taken into or operated in any place if methane can be detected with a permissible flame safety lamp or in amount of more than 1 percent with an electric methane detector.

This recommendation recognizes that electrical equipment, even of permissible type, may be damaged in use so as to present hazard of ignition of inflammable gas. Also, trailing cables may become short-circuited and "blow up." The Pennsylvania law quoted under standard 18–51 applies to the use of coal-cutting machines with enclosed motors, and paragraph 67 of the same section and article provides, "In any gaseous portion of a mine, all motors, unless placed in such rooms as are separately ventilated with intake air, shall have all their current-carrying parts, also their starters, terminals, and connections, completely enclosed in explosion-proof enclosures made of non-inflammable material. These enclosures shall not be opened except by an authorized person, and then only when the power is switched off. The power shall not be switched on while the enclosure is open."

Std. 53. If electrically driven permissible equipment is operated in face regions in a gassy mine, the place should be carefully examined for methane and tests made every 30 minutes by a certified official or other competent person.

This standard recognizes that even permissible equipment may, if not properly maintained, ignite gas; therefore, gas tests should be made to assure that methane is not present. A precaution to safeguard against possible mechanical defects resulting from improper maintenance.

Frequent tests during the time in which the machine must be operated in face regions insures against sudden excessive liberations of gas, which might be ignited.

**Std. 54.* Permissible equipment should be maintained in a good state of repair and in permissible condition, as determined by a rigid examination each week by a person well-informed in the safe use of electricity underground and in the maintenance of equipment; a record should be kept of the defects found and how they are remedied. Repairs should not be made or the electrical parts opened at or near the face while the power is on the machine or cable.

Recommended cables and permissible-type equipment can very quickly become unsafe from misuse and neglect, becoming possible sources of gas ignition from electrical arc and flame. Such

deficiencies as missing bolts, holes burned through the walls of explosion-proof housings, poorly spliced cables, failing insulation, and excessive joint clearance can result in ignition of gas.

The Bureau of Mines schedule of approval *(11)* states that "The requirement of metal-to-metal contact will be construed as having been met for plane flanges if the separation does not exceed a maximum of 0.004 inch." Therefore, it must be realized that if a feeler gage 0.004 inch in size is used and can be inserted in the opening, this does not automatically condemn the case. To be certain that the opening is safe, it must be so tight that a 0.005-inch feeler gage cannot be inserted.

Two gage sizes should be used when inspecting approved compartments, namely, 0.004 and 0.005 inch.

Any apparatus approved by the Bureau of Mines as permissible has affixed to it a plate or label giving the Bureau approval or has such approvel plainly marked on it. To be considered permissible by a Bureau of Mines inspector, any equipment should have on it the Bureau's approval plate and should be in a good state of repair and in safe condition. However, in the case of a small, "single-shot," dry-cell, shot-firing unit, if the approval plate is defaced or lost but the unit is otherwise identical with an approved unit and in good condition, it should be considered permissible by the inspector. With other equipment, if the permissible plate has been lost, the inspector should recommend that the company apply to the manufacturer for a new plate, and he should withhold recognition of the equipment as permissible until such plate has been obtained.

The Pennsylvania Bituminous Mining Law requires *(77, art. XI, sec. 5, par. 11, p. 80; par. 70, p. 99):*

"11. At every mine where electricity is used below ground, for power, there shall be employed a competent mine electrician, who shall have full charge of the electrical apparatus in the mine, but shall be subject to the authority of the mine foreman.

"70. All enclosed motors used underground shall be opened and thoroughly inspected by the person in charge of electrical equipment, or his assistant, at least once each week, and, where necessary, shall be cleaned and repaired. Enclosed switches shall be opened and inspected at least once a month."

Frequent inspection assures good maintenance and continued safe operation and records assist in preventing negligence.

Std. 55. In gassy mines, permissible junction or distribution boxes should be used, where feasible, in making power connections at working faces.

"In places where there is a likelihood of methane accumulating in dangerous proportions, only permissible switches or junction boxes should be used" *(50, p. 17).*

This standard is to lessen gas-ignition sources.

**Std. 56.* Cables for portable or semiportable underground electrical equipment should be provided with suitable taps equipped with fuses, unless properly connected to permissible junction or distribution boxes.

"Trailing cables on portable equipment shall be protected by a fuse or circuit breaker. It shall be optional with the mine operator whether this fuse or circuit-interrupting device is installed in the cable nips or in the circuit to which the cable is attached" *(13, p. 13)*. Cables are not usually protected from overload, and consequently heating and failure of insulation may result; this shows the need for a protective device between the cable and power supply.

Std. 57. Temporary cable splices should be made in a workmanlike manner, mechanically strong, and well-insulated; preferably, when a cable is defective, a stand-by cable should be used and the defective cable sent to the shop for permanent splicing and, if practicable, vulcanizing.

Note to inspectors: Temporary cable splices may be made as follows: (1) The conductors should be joined with proper splicing rings or other suitable devices that will insure a good electrical and mechanical connection. In concentric cables, the outside wires may be individually joined by splicing rings, twisting, or soldering. (2) The spliced conductors should be reinsulated with rubber tape, preferably self-vulcanizing, so as to have the same or greater dielectric strength as the original insulation, and the rubber on each conductor should be covered with P & B tape or its equivalent; both conductors should be covered with rubber tape and finished with P & B tape, or its equivalent.

Permanent cable splices may be made as follows: (1) The conductors should be joined with proper splicing rings or other suitable devices. (2) Splices should be properly vulcanized.

Improperly spliced cables are likely to present fire, contact, arcing, and gas-ignition hazards.

"From the standpoint of greatest safety, spliced trailing cables should not be used in gassy mines. When feasible, damaged cables should be immediately replaced to be later used in a nongassy mine. When not feasible, an adequate splicing program should be enforced" *(49)*.

Std. 58. Permanent cable splices should be made by competent persons in surface or underground repair shops.

Permanent cable splices should be as nearly as practicable like the original cable in the following factors: (1) Conductivity; (2) insulation; (3) mechanical strength; (4) flexibility; (5) size; (6) resistance to abrasion and moisture; and (7) resistance to heat.

Since permanent splicing necessitates vulcanizing, it is obvious that this can best be done in a suitable repair shop where all essential facilities are available.

Std. 59. To prevent excessive heating, the trailing cables or equipment used in conveyor mining should be suspended in long loops rather than tightly coiled.

This precaution should be observed as a fire-prevention measure. Cable in use becomes heated, and when tightly coiled the heat cannot be dissipated properly. This condition has been responsible for numerous mine fires. Loose coiling of the cable permits heat dissipation and reduces the possibilities of overheating with resulting ignition.

Std. 60. Portable pumps and other portable electrically driven equipment should be so located and installed as to constitute the minimum possible fire or man-contact hazard. They should be used only in well-ventilated places.

This recommendation has reference to types of equipment that are not constantly attended while in operation and although portable, in that they may be easily moved from place to place, are a semipermanent type of installation. They should be properly frame-grounded, wired, fuse-protected, and fitted with the power-line connections required for electrical installations by other of these standards. They should be guarded to prevent shock hazard and located in a well-ventilated place to minimize the possibility of igniting gas.

Std. 61. Electric lights on the slope or shaft bottom should be on a separate circuit from the trolley circuit if practicable.

Good illumination is important at all times at slope and shaft bottoms. If the stationary lighting system at such locations receives power from a circuit separate from the mine circuit there is less likelihood of interruptions to illumination.

"Stationary lamps such as are installed at the bottom of shafts and slopes, along sidings, and in underground rooms and stations should have their bases and receptacles made of nonmetallic material, should be well-supported, and, where there is likely to be excessive bulb breakage, should be provided with wire lamp guards. Lamps should not be installed near flammable material or such material stored near a lamp. Where feasible, it is preferable to use 110-volt circuit for lighting installations rather than series lighting with two or more lamps *(45, p. 10)*.

Std. 62. Electric-light circuits should be provided with adequate fuses.

Question has been raised as to the applicability of this standard to a single lamp connected to a direct-current feeder. In such cases, fuses or their equivalent would prevent the common hazard of lamp sockets blowing up in the face of a person renewing lamps underground. Also, a fire hazard can readily exist if a lighting circuit is not equipped with fuse even if it is only a one-lamp installation. It is understood that in mines of the Bethlehem Steel Co. a fuse is inserted in the wire connection even with single-light installations.

Std. 63. Electric-light wires should be supported by suitable insulators and connected to the trolley or power line with clamps.

This standard is to minimize fire hazards.

"Lighting wires shall be attached to trolley or power lines by Universal Test Clip No. 27, which will permit the circuits being disconnected while the base of a broken lamp is removed.

"Light wiring shall be not less than No. 12 B & S gage, rubber covered, and shall be supported on porcelain insulators or split knobs and held free from timbers, coal and rock" *(84, p. 37)*.

Std. 64. The ground connection for lighting wires taken off the trolley circuit should be made to the track circuit.

"All wiring shall be supported on porcelain insulators, and when the track is used as a return for the lighting circuits the return wire shall be attached to the track by bonding to the rail or by attachment to regular bonding" *(84, p. 37)*.

"When the rail is used as a return for lighting circuits, the return wire shall be attached to the rail in an approved manner. This ground connection shall be made of not less than No. 8 A. W. G. copper wire which shall be buried below the surface and carried to the side of the entry and thence on approved insulators to the roof or to a point at least 7 feet above the track" *(13, p. 20)*.

Std. 65. Electric lights should be so placed that they cannot come in contact with combustible material.

This standard is designed to minimize fire hazard.

"Incandescent lamps shall be so placed that they cannot come into contact with combustible material; and shall be so placed that an adequate circulation of air may take place on all sides of them" *(85, sec. 88(c), p. 46)*.

"The wiring to stationary lamps should be put in a conduit or on insulators and have the same care and attention as power circuits. The lamp bulb should not be allowed to rest against timbers or wood of any kind, and should not be covered with improvised shades" *(45, par. 37, p. 10)*.

Std. 66. Electric lights should not be used at or near any working face unless of permissible type.

This recommendation is designed to minimize explosion hazards. Inflammable gas may be ignited by the breaking of an ordinary incandescent light bulb.

Std. 67. Lamp sockets with exposed metal parts should not be used underground.

This standard is designed to lessen shock hazard.

"Stationary lamps such as are installed at the bottom of shafts, along sidings, and in underground rooms and stations should have their bases and receptacles made of nonmetallic material" *(45, par. 37, p. 10)*.

SECTION 19. MACHINERY AND SAFETY APPLIANCES IN CONNECTION THEREWITH

Std. 01. Mining machines should not be loaded on their trucks or moved unless they are equipped with adequate locking devices on the cutter chains and the exposed bits at the end of the cutter bar guarded or removed.

Cutting chains may be started accidently during the maneuvering of a machine, and numerous serious accidents have resulted where chains were not locked when the machine was being moved.

The bits are a source of injury, and especially those at the front of the bar should be removed or shielded to prevent accident by contact with these sharp-pointed objects.

Std. 02. To prevent injury from side slip of caterpillars from rail, the operator of a caterpillar machine should ride on the step provided for that purpose when moving from place to place.

Serious accidents have been caused by the caterpillar treads slipping off a rail and striking the operator. The step was provided to eliminate this type of accident, and it should be used.

Std. 03. Machinemen, drillers, and loading-machine operators should not operate their equipment when any persons are in such proximity as to be endangered.

The necessity for this requirement would appear obvious, as it is impossible for the operators of the equipment to watch out at all times for the safety of others while their attention is fixed on the movements of the machines. A sudden movement of the machine, unexpected by someone standing near by, might result in serious injury.

**Std. 04.* Rock drilling with percussion drills should be done wet. Men drilling rock with auger-type drills should wear either approved-type respirators or use water, if dust is produced.

The purpose of this standard is to protect the miner from breathing silica and other harmful dusts produced during rock drilling. If drilling is done wet, the major portion of the dust is allayed, thus preventing suspension of particles. Another protection is to wear an approved-type respirator, which stops the passage of dust particles to the miner's lungs.

Std. 05. Machinery and belting exposed to possible personal contact should be guarded adequately as indicated below:

a. Gears, sprockets, friction devices, and couplings with protruding bolts or nuts should be completely guarded.
b. Shafting and projecting shaft ends within 6 feet of floor or platform level should be completely guarded.
c. Vertical or inclined belt, chain, or rope drives should be suitably guarded to a height of at least 7 feet above the floor.
d. Horizontal belt, chain, or rope drives within 7 feet of floor or platform should be guarded.
e. Flywheels should be guarded. Where flywheels extend more than 6 feet above the floor, they should be guarded to a height of at least 6 feet.
f. Circular and band saws and planers should be adequately guarded.
g. Locomotive pits should be properly guarded and guard kept in place when the pit is not in use.

The Safety Code for Mechanical Power-Transmission Apparatus *(2)*, approved as an American Standard by the American Engineering Standards Committee in 1927, gives rules for guarding prime movers, intermediate equipment, and driven machines and also has illustrations of guards and requirements for guard construction. The following is abstracted from these rules:

a. Rule 230—Gears. "Gears shall be guarded in accordance with one of the following specifications: * * *"

Rule 231—Sprockets and Chains. "All sprocket wheels and chains shall be enclosed unless more than seven (7) feet above the floor or platform."

Rule 240—Friction Drives.

"*(a)* The driving point of all friction drives when exposed to contact shall be guarded.

"*(b)* All arm or spoke friction drives and all web friction drives with holes in the web shall be entirely enclosed.

"*(c)* All projecting bolts on friction drives where exposed to contact shall be guarded."

Rule 261—Couplings.

"*(a)* Shaft couplings shall be so constructed as to present no hazard from bolts, nuts, set screws, or revolving surfaces.

"Bolts, nuts, and set screws will, however, be permitted where they are covered with safety sleeves or where they are used parallel with the shafting and are countersunk or else do not extend beyond the flange of the coupling * * *."

b. Rule 201—Guarding Horizontal Shafting.

"*(a)* All exposed parts of horizontal shafting six (6) feet or less from floor or working platform, excepting runways used exclusively for oiling, or running adjustments, shall be protected by a stationary casing enclosing shafting completely or by a trough enclosing sides and top or sides and bottom of shafting as location requires."

Rule 203—Projecting Shaft Ends.

"*(a)* Projecting shaft ends shall present a smooth edge and end and shall not project more than one-half the diameter of the shaft unless guarded by nonrotating caps or safety sleeves.

"*(b)* Unused key-ways shall be filled up or covered."

c and *d*. Rule 220—Horizontal Belts and Ropes.

"*(a)* Where both runs of horizontal belts are six (6) feet or less from the floor level, the guard shall extend to at least fifteen (15) inches above the belt or to a standard height—except that where both runs of a horizontal belt are 42 inches or less from the floor, the belt shall be fully enclosed * * *."

"*(b)* Overhead horizontal belts, with lower part seven (7) feet or less from the floor or platform, shall be guarded on sides and bottom * * *."

Rule 221—Vertical and Inclined Belts.

"*(a)* Vertical and inclined belts shall be enclosed by a guard conforming to * * *.

"*(b)* All guards for inclined belts shall be arranged in such a manner that a minimum clearance of six (6) feet six (6) inches is maintained between belt and floor at any point outside of guard."

e. Flywheels located so that any part is six (6) feet or less above floor or platform shall be guarded in one of the following ways:

"*(a)* With an enclosure of sheet, perforated, or expanded metal or woven wire. * * *

"*(b)* With guard rails placed not less than fifteen (15) inches nor more than twenty (20) inches from rim. When flywheel extends into pit or is within 12 inches of floor, a standard toe board shall also be provided. * * *

"*(c)* When the upper rim of flywheel protrudes through a working floor, it shall be entirely enclosed or surrounded by a guard rail and toeboard.

"*(d)* For flywheels with smooth rims five (5) feet or less in diameter, where the preceding methods cannot be applied, the following may be used: A disk attached to the flywheel in such manner as to cover the spokes of the wheel on the exposed side and present a smooth surface and edge, at the same time providing means for periodic inspection. An open space, not exceeding four (4) inches in width, may be left between the outside edge of the disk and the rim of the wheel if desired, to facilitate turning the wheel over. Where a disk is used, the keys or other dangerous projections not covered by disk shall be cut off or covered. * * *"

"*(e)* Adjustable guard to be used for starting engine or for running adjustment may be provided at the flywheel of gas or oil engines. A slot opening for jack bar will be permitted."—(Rule 100.)

f. Guarding of circular and band saws and planers is essential to protect the workers. Modern band saws are equipped with guards at the factory. The guard must be designed for the particular installation and in some cases adapted to the location.

g. "Rule 34. Every Pit and Trap-Door Floor Opening, infrequently used, shall be guarded by a floor opening cover of standard strength and construction which should be hinged in place. While the cover is not in place, pit and trap openings shall be constantly attended by someone or shall be protected on all exposed sides by adequate removable railings that need not be of standard construction" *(3, sec. 3, rule 34, p. 8).*

Many serious and fatal accidents have occurred because the guard or safety device was removed from the machine and machine operated before the guard was replaced.

Std. 06. Surface machines should be adequately illuminated.

Self-explanatory (limited vision is the cause of unnecessary risks).

Std. 07. Adequate clearance should be provided at machine installations and passageways kept free of stumbling hazards.

This recommendation is designed to lessen the hazard of contact with machinery and of falls of persons. Inadequate clearance in places housing machinery is a frequent cause of accidents. Congestion and obstructions breed carelessness and contempt for safe work practices and good workmanship.

Std. 08. Machinery should not be repaired while in motion or oiled while in motion, unless such oiling can be done without danger to the oiler.

This recommendation would appear obvious owing to the widely disseminated information on the hazards of working near moving machine parts. A large number of companies post warning signs near machines to remind employees of the dangers of oiling or repairing machines in operation. Where oil faucets are located outside of guards and moving parts are shielded, the dangers of oiling without stopping the machine are remote.

Std. 09. A guard or safety device removed from any machine should be replaced before the machine is put in operation.

Self-explanatory (obviously the guard is required for safe operation and should be replaced before the machine is used).

Std. 10. Mechanically operated grinding wheels should be equipped with:

a. Safety washers.

b. Substantial retaining hoods, the throat openings of which do not expose more than a 90° segment of any wheel. Preferably, not more than a 60° segment should be exposed.

c. If grinding operations are frequent or constant, a dust-collecting system should be installed to remove liberated dust, or a permissible respirator should be worn by the operator.

The information below has been taken from Safety Code for the Use, Care, and Protection of Abrasive Wheels *(10, pp. 4 and 6).*

a. "Safety washers." Referred to as "protection flanges" in the Safety Code for Abrasive Wheels. "Protection flanges or safety collars are used with abrasive wheels of special shape, so designed that in addition to the usual function of clamping the wheel to the spindle they will also serve to effectively retain the pieces of wheel should it break while in operation." These washers can be tapered, hub, or ring flanges.

b. A retaining hood, referred to in the code as a protection hood, is an enclosure for an abrasive wheel consisting of a peripheral and two side members. Its main function is to effectively retain the pieces of the wheel should it break in operation.

"Hoods should always be used with wheels which are not provided with protection flanges, bands, or chucks.

"Hoods shall be so mounted as to maintain proper alignment with the wheels, and the strength of the fastenings shall exceed the strength of the hood.

"The maximum angular exposure of the grinding-wheel periphery and sides for hoods used on machines known as bench and floor stands should not exceed 90° or one-fourth of the periphery. This exposure shall begin at a point not more than 65° above the horizontal plane of the wheel spindle."

c. "Hoods on machines used for dry grinding and other operations where dust is produced should have provision made for connection to an exhaust system."

The size of such connections should be in conformity with the following specified dimensions:

Diameter of wheel, inches	*Minimum diameter of branch pipe, inches*
6 or less	3
7 to 16	4
17 to 24	5
25 to 30	6

"A modification of the above requirements will be allowed in the case of narrow wheels used for light work where very little dust is generated and where a smaller pipe will satisfactorily remove it.

"These requirements in this paragraph shall not apply to swing-frame and portable grinding machines."

**Std. 11.* Welders and helpers should be provided with proper shields to protect their eyes.

**Std. 12.* Stationary welding locations should be well ventilated and shielded.

"Protectors for Oxyacetylene Welding *(66, sec. 8, p. 63).*

"The style of protector to be used depends on the amount and nature of the work to be done. The more serious hazard of the process is the pathological effect on the eyes which is produced by the radiant energy from the light source. A hazard of lesser degree is small flying masses of molten metal * * * The design (of protectors) should be such that no unfiltered radiant energy is allowed to enter the eye. For this reason it is desirable for operators to wear goggle of style 3 (eyecups of noncorrodible opaque material and parts touching the face of heat-insulating material), face masks, or helmets, whenever two or more operators work in close proximity."

"Protectors for Electric-Arc Welding and Cutting *(66, sec. 9, rules 90 and 91, pp. 64-65).*

"Styles. As in the case of oxyacetylene welding the hazard to be protected against is the intense radiant energy. In this case the ultraviolet radiation is so intense that serious burning of the skin as well as injury to the eyes may result from long exposure. It is therefore necessary to protect the face and head as well as the eyes. The material from which the helmet or shields are made must be opaque to ultraviolet and visible radiation."

"The forms of protector approved for electric-arc welders are the helmet and the shield . . ."

Std. 13. Adequate tools should be available in working places; these should be maintained in good condition.

Many serious accidents have occurred because the tool or tools necessary for a particular job were not available and an ineffective or unsafe substitute tool was employed. Tools with mushroom heads, split or loose handles, or other defects have caused serious accidents. The use of proper tools expedites the work and reduces the hazard of the operation.

Std. 14. Hand tools should be kept in good condition.

A study *(70, pp. 15 and 65)* by the National Safety Council based on 1941 and 1942 data from New York, Ohio, Pennsyl-

vania, and Wisconsin, covering 185,000 compensated cases, shows that hand tools caused 6.15 percent of all compensated occupational injuries. Knives and hammers were the principal tools. The study covered all industries and not solely mining.

Std. 15. If axes are used underground, the combined length of the ax and handle should not exceed 18 inches.

A considerable number of serious accidents are attributed to the use of axes with long handles. The use of axes underground is prohibited by many mining companies while other companies fix the over-all length at 18 inches or less. (It is usually necessary to use a long-handled ax when framing large timbers, and if this work is done where ample free space is available the practice although not safe cannot be condemned because the framing operation would be difficult and laborious with a short-handled ax.)

SECTION 20. FIRE PROTECTION UNDERGROUND

**Std. 01.* Underground storage places for lubricating oil and grease should be of fireproof construction.

**Std. 02.* Lubricating oil and grease kept in face regions or other working locations should be in portable, closed, metal containers.

The mining laws of Pennsylvania *(77, art. XVI, sec. 1, p. 120)* provide in part as follows: "Not more than one barrel of each kind of lubricating oil or lubricant shall be stored in any portion of a mine at one time, and it shall be kept in a fireproof building cut out of solid rock or made of masonry or concrete of sufficient thickness to insure safety in case of fire." The recommendation that "lubricating oil and grease in face regions or other working locations should be in closed metal containers" is designed to prevent spillage and to reduce the fire hazard incident to inflammable materials.

Bureau of Mines Information Circular 7244 *(56)* discusses the storage and handling of lubricants in coal mines.

**Std. 03.* Inside structures (substations, shanties, stables, pump rooms, etc.) should be of fireproof construction, including doors. Where the fireproofing material is in contact with timber or coal, it should not be of metal.

An act of the Commonwealth of Pennsylvania provides:

"Section 1. * * * That within six months after the approval of this act, all buildings inside of any coal mine in Pennsylvania, including engine-houses, pump-houses, stables, et cetera, shall be constructed of incombustible material, approved in writing by the Secretary of Mines; Provided, however, that the time may be extended by the Secretary of Mines, for a period not exceeding six months, upon sufficient cause shown by any person, firm, or corporation, of inability to comply with the provisions of Section one as to the time therein specified."

This State requirement and the Bureau recommendation are justified in order to reduce the possible mine-fire hazard with accompanying dangers to human life and property and also by

reason of disastrous mine fires occurring in the past from the above sources. The second portion of the recommendation is made because metal transfers heat readily from the inside to the outside of the structure. If the metal were in contact with timber, coal, or other combustible material, there is the likelihood that any fire within the structure would be communicated to the material in contact.

It is necessary that underground stables should be constructed of incombustible material and be provided with metal fire doors at entrances because of the presence of hay and straw, which are easily ignited. The mining laws of several States have provisions concerning the fireproofing of stables. The mine fire at the St. Paul No. 2 mine, Cherry Hill, Ill., on November 13, 1909, costing the lives of 256 men, caused by hay set afire at the foot of the intake airshaft, proves the need for this recommendation.

Std. 04. Welding and cutting (with electricity or flame) in gassy mines in face regions and on returns should be done under the immediate supervision of a certified official. No welding or cutting should be done if more than one-half of 1 percent methane is present. In all welding and cutting operations, special precautions should be taken against starting a fire.

This recommendation is designed to lessen the possibility of a mine fire or explosion. Some mine fires and explosions have been caused by welding. Since welding is done either with electricity, which utilizes an electric arc, or with acetylene, which utilizes an open flame, every precaution should be taken to prevent fires or the ignition of gas.

SECTION 21. MISCELLANEOUS HAZARDS

**Std. 01.* An accurate map of the mine, brought up to date at least every 6 months, should be available at the mine and should show accurately:

a. Openings and plan of workings of each vein of coal, and the tunnels and passageways connecting the workings.
b. General inclination, in degrees, of the veins of coal.
c. Elevations, above and below sea level, of top and bottom of shafts, slopes, tunnels, and other permanent stations.
d. Boundary lines and barrier pillars.
e. Locations and elevations of sumps, dams, and other impounded water.

The rate of advance of the working face may be so rapid that a map a year old would show little of the active face regions. It is believed, therefore, that the map should be brought up to date at least every 6 months. This belief is substantiated by the coal-mining laws of several States and Operating Regulations *(28, sec. 28, p. 11)* on coal lands leased from the United States Government, which require that the mine maps be extended every 6 months. It is the custom at some mines to have copies of the mine map posted either in the mine office on the surface or in the foreman's office underground, or both, to aid the mine officials and employees in daily operation of the mine. It would be difficult to operate a large mine with extensive

workings without a map for ready reference. If maps are large or long, they may be placed on rollers to allow ready reference to any part.

The Pennsylvania Anthracite Mining Laws require as follows: "The owner, operator, or superintendent of every coal mine or colliery shall make, or cause to be made, an accurate map or plan of the workings or excavations * * * in each and every seam of coal and the tunnels and passages connecting with such workings or excavations. It shall state in degrees the general inclination of the strata with any material deflection therein said workings or excavations, and shall also state the tidal elevations of the bottom of each and every shaft, slope, tunnel, and gangway, and of any other point in the mine or on the surface where such elevation shall be deemed necessary by the inspector. The map or plan shall show the number of the last survey station and the date of each survey on the gangways or the most advanced workings. It shall also accurately show the boundary lines of the lands of the said coal mine or colliery and the proximity of the workings thereto, and in case any mine contains any water dammed up in any part thereof, it shall be the duty of the owner, operator, or superintendent to cause the true location of the said dam to be accurately marked on said map or plan, together with the tidal elevation, inclination of strata and area of said workings containing water * * *.

"One copy of the said map or plan shall be kept at the colliery.

"When any coal mine or colliery is worked out preparatory to being abandoned, or when any lift thereof is about to be abandoned, the owner, operator or superintendent of such coal mine or colliery shall have the maps or plans thereof extended to include all excavations, as far as practicable, and such portions thereof as have been worked to the boundary lines of adjoining properties; or any part or parts of the workings of which it is intended to be allowed to fill with water, must be surveyed in duplicate and such surveys must practically agree * * *."

The State laws and Bureau recommendations concerning this information are for the protection of miners and the general public because without definite, accurate maps of all underground excavations careless mining often is practiced, lives are jeopardized, and property is destroyed unnecessarily. All the information required is necessary to approach abandoned workings accurately and with any degree of safety, plan future operations, prevent inundations, lessen the possibilities of squeeze conditions, perform recovery operations successfully, isolate fires without hazardous explorations, and continue to mine coal economically and safely.

Std. 02. A ventilation map should be provided and should show:

a. Direction of air currents passing through tunnels, slopes, gangways, airways, cross headings, and working places, by arrows in colors wherever feasible.

b. Location of doors, overcasts, and regulators.

c. Location of telephones, power and trolley lines, and permanent electric equipment.

a and *b*. To facilitate the control and direction of the ventilation in a mine so that each section may have the desired quantity of air for safe and healthful operation, it is advantageous that the map or maps show (1) the direction of the air currents passing through; (2) the location of all doors, air bridges, and regulators. Such a map expedites the arrangements essential before any major ventilation changes are made and provides ready information from which to plan the ventilation of anticipated development so that each and every official can erect the necessary control apparatus as the passageways are driven and avoid interruption of operations because of a lack of ventilation.

Many State mining laws require some of these provisions.

c. A plan showing the location of the communication lines and apparatus and electrical equipment is advantageous in planning safe and efficient operation.

All of this information is of vital importance when recovery operations are planned after an explosion.

Std. 03. When a limit of 200 feet is reached from abandoned workings that cannot be inspected or workings that are filled with water (not in excess of a 150-foot head) or gas, boreholes should be kept at least 20 feet in advance of the face; similarly, 45° angle holes, at least 25 feet deep and not more than 8 feet apart, should be made in each rib. If the head of water exceeds 150 feet, the depth of the boreholes should be increased 1 foot in length for each additional 10-foot head of water.

The necessity of maintaining drill holes in advance of the face in any working place approaching abandoned mine workings suspected of containing dangerous quantities of water or noxious or explosive gases is obvious, and such holes are required by law in many coal-mining States.

The Operating Regulations *(28, sec. 66, p. 24)* governing coal lands leased from the United States Government provide: "In any working place within 100 feet of supposedly dangerous proximity to an abandoned mine or an abandoned section of a mine not known to be free of dangerous quantities of flammable or noxious gases or water, at least two drill holes shall be maintained not less than 20 feet in advance of the face. Such working place shall not be more than 10 feet wide. On each side thereof, drill holes not more than 8 feet apart shall be drilled to a depth of 20 feet at an angle of 45° with the line of the place. In addition to said drill holes, brattice shall be carried within 12 feet of the face at all times."

The Bureau standard recommends 25-foot diagonal or flank holes. This is believed desirable in the interest of greater safety. For example, an entry being driven toward old workings might be paralleling an entry containing dangerous quantities of water, in which event a 20-foot 45° angle hole would only insure a pillar 14 feet in thickness, whereas a 25-foot drill hole would insure a pillar 17.7 feet in thickness.

The recommendation of "a limit of 200 feet" is made because of situations arising where mining is being done in proximity

to old mines worked out perhaps 50 years before with inaccurately mapped areas known to contain water or dangerous gases, or both.

The recommendation of increase in length of borehole, 1 foot for each 10 feet of head over 150 feet, is made because of the greater hazard from such heads of water.

**Std. 04.* When a place is being driven to connect with any working place or with any accessible idle or abandoned place, the condition of these places should be determined to be safe before the connection is made.

To prevent sudden inrush of explosive gas or water and the possible hazards incident to each. Explosions have resulted from cutting through to abandoned places without prior exploration.

Std. 05. Main slope and drift openings should be separated by at least 60 feet of natural ground. (Inspector: This applies only to future openings.)

Mine Safety Board Decision 10 *(63, p. 17)* states as follows: "Such ways of escape shall be so separated by at least 50 feet of natural ground throughout their entire length that damage to one from any source shall not thereby lessen the effectiveness of the other as a means of escape." The Pennsylvania Anthracite Mining Laws provide: "* * * From every lift thereof, worked in such mine, not less than two openings or outlets, separated by a stratum of not less than sixty (60) feet in breadth underground, and one hundred and fifty (150) feet in breadth at the surface * * *." The 60-foot interval assures greater safety from possible collapse of both openings:

Std. 06. In regard to mine openings:

- **a.* Every underground mine should have at least two separate outlets to the surface.
- **b.* Each bed of coal and each level or entry therein should have at least two travelable openings in connection with (directly or indirectly) both main outlets to the surface.
- **c.* It is not necessary that the two main outlets belong to the same mine if persons can travel safely to, and out of, either outlet from either mine.
- **d.* When a new mine is being opened or when a new entry or level is being worked for the purpose of making a connection between the two main outlets, not more than 20 persons should be allowed at any one time in such mine, entry, or level.
- **e.* When only one main outlet is available, due to the final mining of pillars, not more than 20 persons should be allowed in any such section or in any such mine at any one time.

a, b, and *c.* The need for two separate outlets to the surface as means of escape in an emergency has long been recognized. The lack of more than one outlet in the past has resulted in disasters that would have been avoided had there been more than one outlet. The coal-mining laws of many States have such requirements. Mine Safety Board Decision 10 recommends that: "Every underground mine shall have two or more ways of escape to the surface, so arranged and equipped that men can escape quickly."

d and *e*. There are similar requirements in the anthracite mining law. The Operating Regulations *(28, sec. 31, p. 13)* governing coal mines leased from the United States Government provide:

"*(a)* In every mine the lessee shall provide an escapeway or second means of egress to the surface, which, if a drift, slope, or tunnel exit, shall be separated at the surface from the first exit by not less than 50 feet of rock or coal in place; if either is a shaft or both are shafts, the exits shall be not less than 200 feet apart.

"During the course of development of a shaft mine, not more than 10 men shall be employed underground on any shift until connections are made to the second exit.

**Std. 07.* Designated escapeways should be readily accessible from every section of the mine and should be kept in a safe condition, reasonably free from steam, dangerous gases, standing water, ice, and other obstructions.

Provisions similar to these are contained in the mining laws of the principal coal-mining States. Escapeways prevent confusion and anxiety in case of damage or obstruction in a main travelway.

Std. 08. Designated escapeways should be of sufficient height and width to allow men to travel safely.

Self-explanatory.

Std. 09. Direction signs should be posted conspicuously to indicate traveling ways and designated escapeways.

This recommendation is designed to assure that men may readily find their way to escapeways and also that men travel in designated escapeways. Even persons thoroughly familiar with a mine become confused and lose their sense of direction at times, and those unfortunate persons who may become lost because of a lack of knowledge of the mine are greatly assisted by adequate, conspicuously posted direction signs.

**Std. 10.* If the designated escapeways are shafts:

- **a.* They should be equipped with hoist and cage, or with a travelable stairway.
- **b.* If equipped with stairway, it should be of substantial construction, set at an angle not greater than 45° with the horizontal, and equipped on at least one side with suitable handrail; landing platforms should be at least 2 feet wide and 4 feet long at easy and convenient distances, and should be railed properly.
- **c.* If the shafts are not more than 30 feet deep, a ladder may be used in lieu of a stairway. Such ladders should be fastened securely. The rungs should be fastened securely, spaced equally, and not more than 15 inches apart.
- **d.* Ladders or stairways should be kept in good repair, with landings free of debris.

a, *b*, *c*, and *d*. These four recommendations are designed to assure that exit from an escapeway may be made readily in an emergency. Many State mining laws contain similar provisions.

Std. 11. If a designated escapeway is a slope of more than 30°, it should be equipped with stairway or ladder and have landings at intervals not to exceed 50 feet.

This recommendation is similar to an operating regulation *(28, sec. 31(c), p. 13)* governing coal mines leased from the United States Government, which states, "If the escapeway is a slope and more than 25 degrees from the horizontal, steps or a stairway shall be provided. If the floor is slippery or wet, steps may be required where the dip is less than 25 degrees." The provision requiring landings at not to exceed 50-foot intervals is intended to provide convenient points where a person can rest comfortably and to afford some protection if a person should fall.

Std. 12. If a designated escapeway is a drift or a slope inclined less than 45° from the horizontal, incombustible walls (or lining) should extend at least 200 feet from the entrance. If such designated escapeways do not meet these requirements, adequate fire protection should be provided.

Mine Safety Board Decision 10 *(63, p. 18)* in part states, "Where the way of escape is a drift or slope which is inclined less than 45° from the horizontal, the incombustible walls, or lining, and freedom from fire hazard shall extend at least 200 feet from the entrance."

Methods of providing incombustible lining to the first 200 feet of a drift or slope could conceivably be the use of concrete or the application of a cement coating. Fire protection in lieu of lining could be water sprays, water lines and hose, or heavy rock-dust application.

Std. 13. If but one way of escape has incombustible walls or lining, it should be the normal intake airway.

This recommendation forms a portion of Mine Safety Board Decision 10 *(63, p. 18)*. It is designed to insure that, where only one escapeway is fireproofed, it will be used as the intake entrance of the mine.

Std. 14. Manways and travelways should be provided where practicable; they should be maintained in good condition, reasonably free of ice, water, and other obstructions; employees should use them.

Self-explanatory.

Std. 15. All surface openings to underground workings that are not necessary for the operation of the mine should be kept securely closed to prevent unauthorized persons entering, but they should be locked in such a way as not to prevent the escape of employees in an emergency.

Self-explanatory.

Std. 16. All openings necessary for operation of a mine or for escape should be guarded against unauthorized entrance of persons, but so as not to prevent the escape of employees in an emergency.

To prevent intrusion whether induced by curiosity or with malicious intent. Gates that will not obstruct ventilation and

equipped with locks which do not prevent exit are frequently used at mine portals.

**Std. 17.* A check-in-and-out system should be adopted that will provide positive identification, upon the person, of every individual underground. An accurate record of the men in the mine should be kept in a place that will not be affected in the event of an explosion.

An accurate record of all men in the mine will serve as a warning of a possible accident if a check is absent at the end of a shift. Positive identification upon the person of every man underground permits quick identification of bodies recovered from a disaster. If a fire or explosion occurs, an accurate record gives ready information concerning the probable location of men and the number in the mine. The mining laws of various States require some form of check-in-and-out system. Metal checks are a good means of identification. Numbers fastened to electric cap lamps may be an effective substitute, if all lamp changes are recorded.

Std. 18. Barrier pillars should be left when workings are adjacent to old workings suspected of containing water, bodies of dangerous gas, or fire; the barrier pillar should be of such width as may be determined by the engineers of the adjoining property owners and the State mine inspector of the district in which the mine is situated.

This recommendation is to assure that a barrier pillar of sufficient thickness to prevent crushing is maintained to avert a possible inflow of water or gas from old workings if mining is being done in the vicinity of an abandoned area.

The Pennsylvania Anthracite Mining Law requires barrier pillars, the thickness of which must be determined by the engineers of the property owners and the district mine inspector.

Std. 19. In pitching coal veins, pillars of adequate thickness should be left to support levels and gangways.

This standard was formulated to prevent possible mishap along haulageways where sufficient width of pillar is not left intact to prevent crushing, and possible sliding down the pitch. The Washington Mining Law states *(86, sec. 47, p. 25):* "It shall be unlawful for the owner, operator or superintendent of any mine to loosen or remove, or cause or permit to be loosened or removed from its original position, any coal * * * within twenty-five (25) feet of any level or gangway, or any parallel airway to any level or gangway, except for the purpose of driving air and escapeways, crosscuts and such other passages as may be necessary for the proper operation of the mine * * *."

Std. 20. Underground stables should be ventilated by separate splits of air, with vents to the return air courses.

This recommendation is to assure that, in case of a fire in an underground stable, the smoke and noxious gases created are conducted directly into the return air course to safeguard and protect the men at the working faces and throughout the mine. A provision in the West Virginia law *(87, art. 2, sec. 20, p. 25)*

is as follows: "The air current used for the ventilation of the stable shall not be intermixed with the air current used for ventilating any other portion of the mine, but shall be conveyed directly to the return air current."

Many lives have been lost because of asphyxiation from fumes and smoke emitted by a stable fire.

**Std. 21.* Hay or straw should be stored in a fireproof structure apart from the stable.

Obviously to isolate possible fires started in these readily combustible materials.

**Std. 22.* Smoking should not be permitted in any mine.

Records show that the use of matches and smoking has caused fires and gas ignitions, with resulting general or localized explosions, particularly in the so-called "nongassy" mines. All coal mines are potentially gassy.

Std. 23. Search of employees for smoking material, matches, and other lighting devices should be made frequently and in a manner to assure that such articles are not being carried into the mine.

To effectively prevent the practice of smoking underground, frequent searches should be made for such articles as are mentioned in this standard. Random searching at irregular times has been found more effective since employees are kept in suspense and are less likely to attempt violation of this important rule. Some State laws require a periodic search of all underground employees for smokers' articles and flame-making devices.

**Std. 24.* Only permissible portable electric lamps, preferably cap lamps, should be carried by all persons for illumination in the mine.

This recommendation is made to lessen fire and gas-ignition hazards and is substantiated by Mine Safety Board Decision 1 *(62)* as follows: "The United States Bureau of Mines recommends that: 1. In all coal mines the portable lamps for illumination be permissible, portable, electric mine lamps * * *."

**Std. 25.* Protective hats should be worn by all employees, officials, and others while on duty in mines and also in work on the surface where there is danger from falling objects.

**Std. 26.* Protective footwear should be worn by employees, officials, and others while on duty in and around mines.

**Std. 27.* Gloves should be worn when material is handled that may injure the hands.

**Std. 28.* Men should be required to wear safety goggles when using grinding tools and when doing other work where particles are likely to fly. Preferably, all mine employees should wear goggles at all times in and around mines. Where corrective-lens goggles are needed, they should be used.

Std. 29. Haulagemen and others who work around machinery should wear snug-fitting clothing and have trouser legs held with boots or puttees, tucked inside socks, or otherwise fastened. When electric cap lamps are worn by such employees, the lamp cables should be concealed under their clothing.

The value of protective clothing certainly is unquestionable now, and since the advent of protective apparel both the frequency and severity of head and foot injuries have decreased tremendously.

Goggles have prevented numerous eye accidents, and certainly preservation of the eyes is a worthwhile consideration, even though some discomfort may be experienced when performing certain operations.

Information Circular 6724 *(29)* describes proper and suitable types of protective apparel and indicates by tables the reduction in accidents at certain mines that has resulted from the use of protective clothing.

GENERAL SAFETY CONDITIONS

SECTION 22. SUPERVISION

NOTE: "Certified" as used in connection with officials or specialized employees in this circular means persons who are adjudged competent and have certificates issued by the State department of mines. The Bureau of Mines believes that State certification of mine officials is desirable.

Std. 01. The foreman or other person in charge of underground operations, and all assistant foremen should have certificates of competency from the State.

In coal-mining States that issue certificates of competency, it is mandatory with certain specified exceptions that only certified foremen be employed. A penalty is usually prescribed for violation of this order.

Mine Safety Board Decision 18 *(63, p. 27)* states as follows: "In the interest of safety in coal mining, the United States Bureau of Mines recommends that:

"1. The foreman regularly in charge of underground operations and also any person who, in the absence of the foreman, may be placed in temporary charge should each have a certificate of competency from the State to act as mine foreman."

Std. 02. Records of foremen's certificates should be kept at the mine.

It is desirable that a record be kept at the mine of all foremen holding certificates of competency so that their legal right to act as foremen is evident.

Sometimes a question concerning certification arises, and complete records simplify verification.

**Std. 03.* Each working place should be inspected for safety by a certified official at least twice each working shift and as many more times as may be necessary. A sufficient number of officials should be employed to carry out this recommendation.

It is believed that one contributing cause to the high accident rate in coal mines is lack of supervision, which in most mines is the result of too large an area being assigned to a foreman. Many State mining laws require at least one official visit to

each working place each shift. The anthracite mining law requires at least one official visit to each working place each shift.

Some mining companies are requiring more than two visits to each working place by certified officials. As evidence of his visit, the official should mark his initials and the date near the face during each visit. Various colors of chalk, one for each shift, have been used in some mines so that the mark of each shift official may be found quickly.

**Std. 04.* Idle or abandoned sections of a mine should be inspected for gas and other dangerous conditions by the foreman or assistant foreman immediately before other employees are permitted to enter such sections, to assure the safety of the workmen.

The laws of most coal-mining States require the examination of all working places for gas and dangerous roof before the workmen are allowed to enter them. Idle or abandoned working places into which it is intended to send men would become active working places, therefore a prior examination should be mandatory.

Numerous instances have been recorded where men were overcome by gases or were lost and gas was ignited in abandoned workings. Official examinations of abandoned places before workers are permitted to enter is certainly a worthwhile precaution.

**Std. 05.* Air courses should be traveled at least once each week by a certified mine official, who should leave his initials and the date; air courses that might be used as escapeways in case of emergency should be inspected and defective conditions remedied promptly.

The laws of the various coal-mining States make definite requirements as to the examination of air courses and openings which give access to abandoned workings and falls.

Obviously, air courses must be maintained if an adequate volume of air is to be coursed as desired through the mine. Frequent examination insures definite knowledge of conditions.

The anthracite mining law requires weekly inspection of airways.

Std. 06. All underground entrances to any places not in actual course of working or extension should be properly fenced across the whole width of such entrances to prevent persons from inadvertently entering them.

This recommendation is a precautionary measure predicated upon experience and is required by law in most coal-mining States. Frequently persons wander into abandoned places in search of material or when obsessed with curiosity and are severely injured. Most persons respect a warning sign and refrain from exploring where possible dangers are present, therefore the danger sign is a definite safeguard.

The Pennsylvania Anthracite Mining Law states: "All underground entrances to any places not in actual course of working or extension shall be properly fenced across the whole width of such entrances, so as to prevent persons from inadvertently entering the same."

Std. 07. All entrances to dangerous places should be fenced off and suitable danger signs provided at safe distances from the existing hazard.

A precautionary measure to avert accidents to curious persons and those who may enter dangerous places in the hope of finding supplies or materials that can be utilized.

Std. 08. A statement of all dangerous conditions observed should be recorded daily in a book, signed and dated by the mine foreman.

This standard recommends a generally accepted good practice and is a record of existing conditions which in a measure affixes a responsibility for the correction of those hazards that may endanger the lives of underground personnel. Such records are required by law in most coal-mining States.

SECTION 23. SAFETY ORGANIZATION

Std. 01. Safety engineers or directors should be employed for mines employing 150 persons or more.

A well-planned safety program can only be made to function properly if directed by someone responsible for safety alone.

Std. 02. A safety organization of officials and employees should be established if practicable.

The benefits derived from a safety organization in which employees and officials participate actively are manifold because many of the most practical solutions of perplexing safety problems originate from the employee who is performing the work where the hazard exists. There may be a tendency to curtail safety activities during the war owing to the increase in working time and numerous other activities attendant and incident to the prosecution of the war, but it must be remembered that industrial accidents retard productive effort and consequently slow up the war program. The organization may be essentially smaller in membership, but the benefit of joint responsibility for the furtherance of safety must not be overlooked.

Each worker is vitally concerned or should be, and his views and opinions should be solicited where safety is involved. His responsibility for continued safe operation must also be stressed.

The following are quotations from various Bureau of Mines publications concerning safety organizations:

"Organization at coal mines to obtain the best results in preventing accidents must include:

"10. Establishment and maintenance at each mine of local mine safety associations, to be composed of all officials and representatives of the different classes of employees and to meet at least once each month. At these meetings reports on matters of health and safety should be submitted and discussed and action taken to prevent the recurrence of any fatalities and injuries that have happened since the last meeting. This organization if efficiently conducted will sustain interest and insure

joint cooperative effort by all officials and employees in promoting health and safety. Rewards or medals will stimulate effort" *(80, p. 130)*.

"To be successful, any safety program must have the continued support and cooperation of the employees. It is believed that in most instances their support can best be won by the establishment and maintenance of a safety organization for employees which may meet monthly to discuss the accidents that have occurred during the month and suggest ways of preventing such accidents in the future. Entertainment of some sort or speakers may be provided for each meeting; at nearly every mine there is usually good musical or other talent that can be utilized. To encourage attendance, many operators furnish prizes such as safety shoes, safety hats, or clothing, which are drawn by lot or otherwise distributed.

"Meetings of this type, at which the men and officials meet in a friendly and cooperative spirit, have done much to improve contact relations between the company and the local miners' organization" *(40, p. 3)*.

"Certain kinds of other safety educational and safety inspirational work cannot be done while the employee is at work in the plant or mine; these include the discussion of accidents, how they occurred, and how similar accidents can be avoided. To educate, it is not only necessary to tell the employee, it is also necessary to try to make him think. Probably the most practical way to promote thought on any given subject is to provoke discussion; this can be done to good advantage in open meetings of employees. The safety meeting such as is held under the auspices of the Holmes Safety Chapter offers the opportunity to sell safety to the employees. When the employee becomes 'sold' on the idea of safety he will generally become more amenable to discipline. When complete cooperation in safety work has been secured from the industrial worker, a large portion of the accident-prevention problem in industry will be solved. In many communities the Holmes Safety Chapter has been found valuable in securing this cooperation" *(24, p. 7)*.

Std. 03. A safety committee, including workmen and officials, should make periodic inspections of the mine and submit recommendations for correcting hazards observed.

A joint inspection of a mine by workmen and officials often discloses valuable information if the entire examination in all respects is confined to the search for hazards, and faulty work practices and the discussions and decisions are based entirely on the findings of the committee without prejudiced opinions or presumptions. Workmen often notice hazards which are not observed by the foreman, especially if his mind is preoccupied with the many problems that confront him daily.

**Std. 04.* Accidents involving injuries to persons and other serious accidents should be investigated and records kept of such investigations.

"Obviously, if accidents are to be prevented the cause and type of accident must be known in order that intelligent steps may be taken to prevent their recurrence. Therefore, preliminary to beginning a safety program in which the Bureau's assistance has been requested, a Bureau engineer first studies the accident records and reports, usually tabulating the accidents according to cause and occupation if this is not already being done by the operator. A study of these reports and tabulations shows how and where most of the accidents occur. The completeness of this picture depends on the type of report required by the company. Unfortunately the accident reports and records of many (probably of most) companies are very meager insofar as concerns the details of the actual cause of the accident. The cause of the injury (fall of rock, run over by cars, etc.) is given, but little or nothing is said regarding the contributing factors leading to the accident—absolutely necessary information if adequate, well-directed steps are to be taken to prevent similar accidents in the future" *(40, pp. 1-2)*.

Std. 05. Responsibility for accidents should be placed, if it is feasible to ascertain such responsibility.

Self-explanatory.

Std. 06. Records should be kept of all lost-time accidents, and they should be summarized monthly, as well as annually, and studied with a view to making needed corrections in practice.

This standard differs only slightly from standard 23–04, and the same explanation is applicable.

Std. 07. Joint safety meetings of men and officials should be held at least monthly if practicable.

"Well-planned safety meetings of employees and officials at which safety rules, safety measures, and accidents can be fully discussed are of much value in educating employees and obtaining their cooperation in safety work. Able speakers, motion pictures dealing with safety, and other means of teaching lessons in safety can also be part of such meetings. The Holmes Safety Association, sponsored by the Bureau of Mines, is an excellent medium for conducting work of this kind" *(32, p. 7)*.

Std. 08. A bulletin board should be provided and posted with suitable bulletins, if available.

"Organization at coal mines to obtain the best results in preventing accidents must include:

"13. Advertising to miners and mine officials and their families, health and safety through the use of bulletin boards, lectures, motion pictures, mine rescue demonstrations, first-aid contests, contests among mines, or groups of mines to establish the lowest accident rates, athletic events, placards, and records of unsafe practices of officials and workmen posted at working places" *(80, p. 131)*. Attractive bulletin boards draw attention, and once interested an observer will usually read the pertinent information posted on the board; cartoons are frequently used to explain unsafe work habits and dangerous practices.

SECTION 24. SAFETY RULES AND STANDARDS

Std. 01. Special company rules regarding mine safety should be adopted and published; they should be approved by the State agency governing mining where such approval can be obtained.

It is desirable that every mining company formulate and put into effect safety rules and regulations governing each of the various phases of mine operation. These rules should not conflict with State mining laws but should augment them. In some States such rules, when approved by State authorities, become a part of the law so far as the particular mine is concerned. In this connection, the general mining laws of Illinois provide as follows *(43, art. 23(d), p. 54):* "It shall be the duty of every operator to post at some conspicuous point at the entrance to the mine, in such manner that the employees of the mine can read them, rules not inconsistent with this Act, plainly printed in the English language, which shall govern all persons working in the mine. And the posting of such notice, as provided, shall charge all employees of such mine with legal notice of the contents thereof." Information Circular 6820 *(39)* gives suggestions concerning coal-mine safety rules.

Simple, applicable rules are essential to efficient conduct of any program.

Std. 02. New employees should be fully instructed regarding the company safety rules and regarding the particular hazards incident to their work; this applies to both experienced and inexperienced personnel.

Std. 03. Where practicable, new employees should be furnished with copies of the mine safety rules.

It would appear obvious that safety rules and regulations are useless unless the employee is thoroughly conversant with them, particularly those rules that apply to the work the employee is called upon to perform. Hence, new employees should receive a copy of the company rules and should receive instruction concerning the hazards incident to their work and the safety rules that have been formulated as a result of experience to safeguard the employee against such hazards.

Std. 04. Employees should become conversant with the State mining law with the aid of such instruction and assistance as may be obtained from the company or available educational agency. Compliance with the mining law should be required of all employees.

Unquestionably, the employee should be informed concerning the sections of the mining law that pertain to his daily work. Such sections of the law might well be incorporated in the company safety rules and, as pointed out in Information Circular 6820 *(39, p. 4)* probably the best way to acquaint employees with safety rules, as well as with the provisions of the mining law, would be at regular safety meetings such as Holmes Safety Chapter meetings.

SECTION 25. FIRST AID AND MINE RESCUE

Std. 01. All employees (underground and surface) should be given first-aid training as soon as possible after being employed.

"If first aid is rendered promptly the patient can be turned over to the physician or surgeon in a condition that makes his task of rendering medical treatment and care much easier. Checking the loss of blood, preventing shock, lessening pain, and immobilizing fractures conserve the strength of patients; in consequence, when medical care is obtained the patient's chance of recovery is greatly enhanced.

"The principal objects of first aid are:

"1. Prevention of further injury.

"2. Checking of conditions known to be endangering life.

"3. Protection of injuries from infection and other complications.

"4. Making the patient as comfortable as possible to harbor his strength.

"5. Transportation of the patient to medical assistance, where necessary, in such a manner as not to complicate the injury or subject the patient to any more discomfort than is absolutely necessary" *(64, p. 3)*.

"First-aid training is an essential part of safety programs in the mining industry, but it is only a means to an end; first-aid training will not eliminate accidents, but unquestionably it is of considerable value in any accident-prevention program. Numerous features should be incorporated in any efficient, well-developed safety plan; in addition to first-aid training safety work, to be reasonably effective, should include the establishment and maintenance of a safety organization, safety competions between mines or sections of mines, safety-inspection committees, accident-investigation committees, safety meetings of mine officials, safety bulletins and posters, employees' safety publications, Holmes Safety Chapters (which provide for monthly safety meetings of all employees), and numerous other activities looking to safe operation of mine or plant. These features are supplementary to the fundamentals of safety—adequate and effective supervision and discipline. Years of experience, however, have demonstrated that first-aid training is a good accident-prevention auxiliary and should be made an integral part of every company's safety program. Many safety organization plans have failed because they have been based upon the assumption that the supervisory force should be given full authority and responsibility for achieving safety and eliminating accidents and that the workers, who are most vitally concerned, are nonessential. First-aid training causes employees to feel that they have a personal and full participation in the safety program and is now available so readily that no individual or organization has any valid excuse for not having it" *(23, p. 1)*.

Std. 02. If feasible, additional first-aid training should be given to all employees annually.

"First-aid training, to be effective, should be renewed at least once each year and more often if possible, and as new employees are taken into the organization they should be trained by the competent staff of trained instructors available. Constant effort is required to keep the first-aid movement alive, and it is necessary to have a number of trained teams at each mine if the utmost benefit is to accrue from this safety method. The team members generally should be compensated in some manner to keep the interest alive; the majority of mine operators do not pay the teams for the training time, but teams are sent to various State or national meets each year, which gives the first-aid workers an enjoyable trip. All the teams at the mines of one large coal-mining company are given an opportunity to compete for the honor of representing the company at such meets. One mining company states that whenever it has 5 or 6 new employees who have not had first-aid training a class is formed for instruction in first aid, thus keeping the plant trained as nearly 100 percent as possible" *(23, p. 16)*.

**Std. 03.* Adequate first-aid material should be provided on the surface and underground and kept in clean, usable condition.

The adequacy of the supply can only be determined by the size of the mine and the number of men employed. In order to prevent further infection of wounds, first-aid material should be kept clean, preferably sterile.

Std. 04. At least 10 sets of oxygen breathing apparatus and at least 6 gas masks and necessary accessories should be available in each mining district for use if a mine fire or explosion occurs. This equipment should be available at centrally located rescue stations owned by the State or operators in the districts, or be owned by individual companies. This equipment should be readily available at all times for transportation and use.

"Every mining district, regardless of the size of the mines, should have mine rescue stations readily available to all its mines, because no underground mine is free of the possibility of hazardous atmospheric conditions" *(27, p. 2)*.

Ten sets of self-contained oxygen breathing apparatus are necessary for recovery work in that 10 is the number required for equipping two squads. For proper, safe recovery work, one squad of five men should be held in reserve at the fresh-air base while another squad of five men is in action.

Six gas masks are sufficient in that all that is necessary to put one back in service after being used is to change the canister, which can be done in a few minutes. Six would equip a squad of five men and afford a spare. Only permissible types of self-contained oxygen breathing apparatus and gas masks should be recommended.

Any one of the Bureau-approved type N universal gas masks may be used in mines under the limitations and with the precautions given in Miners' Circular 35 *(25, pp. 19-21)*.

The word "universal" is used to describe these masks rather than such words as "all-service" and "all-purpose," which apply only to the mask of a particular manufacturing company.

For any one of these masks to be approved, it must be made up wholly of the parts given in the approval. For example, the M. S. A. gas mask canister is not to be used with the Acme or Willson universal gas masks or vice versa.

When an engineer or inspector is asked to recommend gas masks for mine use, he should make it clear that the Bureau has approved a number of type N masks, the names of which can be obtained from the most recent list published.

Some States maintain mine rescue stations convenient to the majority of the mines in a certain district. Cooperative or joint-owned stations are also maintained by coal-mining companies in some parts of the coal regions.

The State of California requires *(14)* that cooperative stations be within 2 hours' travel time (during the worst season of the year) of the mines they are to serve. This distance seems a reasonable criterion by which to judge the availability of a mine rescue station insofar as distance is concerned.

Std. 05. When training facilities are available, at least 12 men should be trained in mine rescue work at mines having more than 100 employees; mines having 100 employees or less should have a proportionately smaller number trained.

"At least 5 men (10 would be better) from each mine should be trained in the use of oxygen breathing apparatus. Every central rescue station should have in training at all times at least 5 men from each mine affiliated with the station" *(27, p. 3)*. However, this quotation from Miners' Circular 39 applies only to mines of considerable size. Whether or not mine rescue training should be recommended at mines in which less than 50 men are employed should be decided by the inspector and district or subdistrict office of the Bureau of Mines.

Std. 06. Additional mine rescue training should be given monthly if training facilities are available.

"A definite training schedule should be maintained, each crew having a prearranged date or dates each month for training" *(27, p. 3)*.

No mine rescue squad can perform effectively and with a degree of safety unless it receives training periodically because familiarity with the apparatus is absolutely essential for efficient recovery operations.

Std. 07. Mine officials should take an advanced mine rescue course when such course is available.

"The Bureau's long experience at mine fires and explosions in nearly every mining field in the United States over many years indicated the necessity for a more complete course of training for those who are likely to be called upon to render assistance in mine disasters, and particularly for those who may have to plan and direct rescue and recovery operations. With these ideas in mind, an outline for an advanced mine rescue training course was prepared and tried out in the field during 1925" *(22, p. 4)*.

Std. 08. Self-rescuers should be readily available to all underground employees.

Note that this recommendation does not state who should furnish the self-rescuers. The self-rescuer is a protection for the individual; in some cases, the individual miner purchases his own; in other cases, mining companies supply them and prescribe where they shall be kept.

"The purpose of the respirator is to help miners escape at times of mine fire or explosion by providing temporary protection from carbon monoxide" *(25)*.

Many mine-safety men believe that every man entering a mine should at all times wear a self-rescue respirator, as mine disasters usually occur when least expected. The wearer of a self-rescue respirator, if still alive after an explosion or during a fire, may have a much greater chance of escaping than a man not so equipped, and its use may mean the difference between getting out alive or perishing in the effort *(25)*.

Std. 09. If self-rescuers are available, employees should be trained in their use. Self-rescuer cases should be maintained in airtight condition.

Obviously, familiarity with apparatus is essential before it can be used safely or effectively. The cases should be airtight to prevent deterioration of the chemical used for removing the carbon monoxide.

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